



**UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION 8**

IN THE MATTER OF:)	Docket No.
Hecla Mining Company)	Proceeding Under Section 7003 of the Resource
6500 N. Mineral Drive, Suite 200)	Conservation and Recovery Act,
Coeur d'Alene, ID 83815-9408)	as Amended, 42 U.S.C. § 6973
EPA ID No. UTD982589848)	
Respondent)	
)	
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)	

ADMINISTRATIVE ORDER ON CONSENT

WHEREAS, the Parties to this Administrative Order on Consent (the "Consent Order"), Hecla Mining Company and the United States Environmental Protection Agency, Region 8 ("EPA"), have agreed to the entry of this Consent Order, and have agreed that this Consent Order supersedes the Order Requiring Monitoring, Testing, Analysis and Reporting, Docket No. RCRA-8-99-06, issued under Section 3013 of the Resource Conservation and Recovery Act, ("RCRA") as amended, 42 U.S.C. § 6934(a) ("3013 Order"), it is therefore agreed and ordered that:

I. JURISDICTION

1. EPA has the authority to issue this Consent Order pursuant to Section 7003(a) of RCRA, 42 U.S.C. § 6973(a).
2. Hecla Mining Company ("Hecla" or "Respondent") agrees to undertake all actions required by the terms and conditions of this Consent Order. In any action by EPA or the United States to enforce the terms of this Consent Order, Respondent consents to and agrees not to contest the authority or jurisdiction of EPA to issue or enforce this Consent Order. Respondent's participation in this Consent Order shall not constitute or be construed as an admission of liability or of EPA's findings or determinations contained in this Consent Order and is not an acknowledgment by Respondent that any past or present handling, storage, treatment, transportation or disposal of any solid waste or hazardous waste may present an imminent and substantial endangerment to health or the environment at the facility.
3. EPA maintains sole jurisdiction to implement and regulate the RCRA program within the exterior boundaries of the Shivwits Band of Paiute Indian Reservation.
4. This Consent Order is based upon the administrative record compiled by EPA and incorporated herein by reference. The record is available for review by the Respondent

and the public at EPA's Regional Office at 999 18th St., Suite 300, Denver, CO 80202-2466.

II. PARTIES BOUND

5. The provisions of this Consent Order shall apply to and be binding upon Respondent and its officers, directors, employees, agents, contractors, successors, and assigns.
6. No change in ownership, corporate, or partnership status relating to the facility described in this Consent Order will in any way alter the status or responsibility of Respondent under this Consent Order. Any conveyance by Respondent of title, easement, or other interest in the facility described herein, or a portion of such interest, shall not affect Respondent's obligations under this Consent Order. Respondent shall be responsible and liable for any failure to carry out all activities required of Respondent by this Consent Order, irrespective of its use of employees, agents, contractors, or consultants to perform any such tasks.
7. Respondent shall provide a copy of this Consent Order to all contractors, subcontractors, laboratories, and consultants retained to conduct or monitor any portion of the work performed pursuant to this Consent Order within seven (7) calendar days of the effective date of this Consent Order, or on the date of such retention, and Respondent shall condition all such contracts on compliance with the terms of this Consent Order.
8. Any documents transferring ownership and/or operations of the facility described herein from Respondent to a successor-in-interest shall include written notice of this Consent Order. In addition, Respondent shall, no less than thirty (30) days prior to transfer of ownership or operation of the facility, provide written notice of this Consent Order to its successor-in-interest, and written notice of said transfer of ownership and/or operation to EPA.

III. FACILITY DESCRIPTION

9. Respondent is a corporation organized under the laws of the State of Delaware, operating a waste facility ("Facility") on tribal trust land within the exterior boundaries of the Shivwits Band of Paiute Indian Reservation.
10. Pursuant to an Amendment to Lease entered into between Hecla and the Shivwits Band of Paiute Indian Tribe (the "Tribe") on September 25, 1995, the Respondent leases and is responsible for a parcel of property described approximately as: beginning at a point N 59°30' West, 1510 feet from the Southeast Corner of Section 5, Township 42 South, Range 17 West, Salt Lake Base and Meridian, thence West, 560 feet, thence North 21° 40' West, 415 feet; thence North 34°30' East, 250 feet; thence East, 526 feet; thence South 4°26'31" East, 590 feet to the point of beginning. The parcel of land lies within the SE1/4, the E1/2 SW1/4 and S1/2NE1/4, Section 5 and the NW1/4, NE1/4, Section 8, Township 42 South, Range 17 West, Salt Lake Base and Meridian, within the reservation of the Shivwits-Paiute Band Indian Tribe, within Washington County, Utah (the "Leased

Premises”).

11. The Facility is located on approximately 8.28 acres of the original site lease and principally consists of a 500-foot diameter pond (“Impoundment”) and adjacent evaporation pond. The Impoundment contains an open leachate collection trench partially constructed around its southwest side that collects leachate and drains it into the evaporation pond also located on its southwest side.
12. Groundwater near the Facility occurs in a confined limestone aquifer at a depth of 280 to 360 feet from the surface.
13. The groundwater has a total dissolved solids level in excess of 3000 mg/l, which is unsuitable for potable use without treatment.
14. The Facility is located on the eastern slope of the Beaver Dam Mountains in an area that drains generally to the east towards the Santa Clara River.
15. There are no streams on or adjacent to the Facility; the nearest surface water is the Santa Clara River, a tributary of the Virgin River, approximately 2.5 miles away.
16. Runoff from the Facility and Impoundment outside of the collection trenches drains in a northeasterly direction into a catchment basin currently maintained by OMG Americas, Inc.
17. Livestock grazing and mining have comprised the two major uses of land in and around the Facility. Although no grazing leases presently exist on the Facility, cattle have been observed in the immediate area. The Impoundment is enclosed by a fence and gate adequate to keep livestock out.
18. Birds and other wildlife may access and ingest contaminants from the Facility, leachate collected in adjacent trenches and evaporation pond, and seepage occurring on the Facility’s south side.

IV. FINDINGS OF FACT

Ownership and Operation History:

19. Beginning in March 1984 and continuing through 1988, the St. George Mining Company (“SGMC”) constructed and operated a mill and tailings disposal facility on approximately 180 acres of tribal trust land located in Section 5 and Section 8, Township 42 South, Range 17 West, Salt Lake Base and Meridian, leased from the Shivwits Band of Paiute Indian Tribe (the “Site”). The Site consists of thirty (30) acres for production, seventy (70) acres for general storage and waste disposal and eighty (80) unused acres.
20. During SGMC’s period of operation, SGMC produced and disposed of wastes in three asphalt-lined waste impoundments on the Site, including the Impoundment (a/k/a Pond 2), and Ponds 1C, 2A, 3A, 3B North and 3B South.

21. At the end of SGM C's operations, the waste containment system on the Leased Premises consisted of eight ponds containing various amounts of waste solution and solids.
22. Hecla purchased the Site operation and lease from SGM C on or about March 19, 1989, for the purpose of continuing gallium and germanium extraction operations and producing zinc and silver by-product. As part of the proposed operations, Hecla planned to reprocess the wastes historically produced and disposed of on the property and utilize the existing waste areas for additional waste disposal. The waste impoundment facilities were designed to contain both existing waste and tailings to be produced from Hecla's operations.
23. Hecla submitted a Part A RCRA permit application in February 1990 to treat, store, and dispose of hazardous wastes. On May 8, 1990, Hecla provided EPA Region VIII with a summary of the facility's acid leaching operation, wherein Hecla concluded that because the acid leaching operation at the facility constituted mineral beneficiation, any wastes generated from this process were not hazardous waste as defined by RCRA Subtitle C regulations. Following EPA's concurrence with Hecla's conclusion, Hecla withdrew its Part A application on November 13, 1990. EPA assigned Hecla EPA hazardous waste identification number UTD982589848.
24. Hecla produced germanium concentrate and cathode copper on the Site from February to August 1990.
25. Hecla conducted cobalt sulfate operations on the Site from November 1992 until it sold the Site operation and lease to OMG Americas, Inc. ("OMG"), a wholly owned subsidiary of Mooney Chemicals, Inc., in August 1995.
26. Between the period November 1992 and August 1995, Hecla placed wastes from the cobalt sulfate operation into ponds 1A/B or 3A. The material was subsequently moved to the Impoundment.
27. At the time Hecla sold the Site operation and lease to OMG, Hecla entered into an Amendment to Lease with the Shivwits Band of Paiute on September 25, 1995, for the purpose of leasing and operating the Impoundment.
28. Hecla occupies the Leased Premises for maintaining a tailings impoundment for permanent disposal of wastes, including mined ores, mineral beneficiation wastes, and contaminated soils excavated and impounded from Hecla's and SGM C's industrial operations on and in the immediate vicinity of the Leased Premises.
29. Pursuant to the Purchase and Sale Agreement ("Agreement") entered between Hecla and Mooney Chemicals, Inc., on or about August 2, 1995, Hecla agreed to reclaim and consolidate waste materials, old liners and excavated soils from areas on-site, including but not limited to the surge pond and pond 2A, the plant, office/shop and ore storage areas into the Impoundment prior to closing. Per this Agreement, Hecla was required to excavate all soils and waste materials above 80 parts per million for arsenic, lead and total petroleum

hydrocarbons. These materials were placed untreated in the Impoundment.

30. Pursuant to the Agreement, Hecla agreed to move the waste materials contained in ponds 1A/B and 3A into the Impoundment by September 30, 1996. At the time of the Agreement, Hecla had already placed waste materials and old liners from pond 1C, 3B north and 3B south into the Impoundment.
31. Hecla currently employs a local contractor to perform maintenance of the leachate collection trench and evaporation pond at the facility. Hecla's corporate office is responsible for Hecla's environmental compliance with respect to the Leased Premises.

Inspections, Investigations, Studies, Evaluations, and Analytical Information:

32. On November 16, 1998, EPA performed a compliance evaluation inspection ("inspection") under RCRA and National Pollutant Discharge Elimination System authorities at the Impoundment. This inspection included sample collection.
33. As a follow-up to the November 16th inspection and sampling results, EPA sent Hecla a letter dated January 15, 1999, requesting information relating to the processes conducted and wastes generated during the years of Hecla's operations; the cleanup and management of feedstock, sludges, liquids, and ponds as part of the transfer of ownership; the pond rehabilitation, waste removal and relocation and pond refurbishment of existing ponds; and the construction and closure of the Impoundment.
34. Hecla timely responded to EPA's January 15, 1999 information request in a letter and attachments dated February 12, 1999.
35. Based on review of the February 12, 1999, response and results of EPA sampling conducted during the November 1998 inspection, EPA issued Hecla a formal Information Request pursuant to Section 3007 of RCRA, 42 U.S.C. § 6927, and Section 308 of the Clean Water Act, 33 U.S.C. § 1318, on June 1, 1999.
36. EPA received Hecla's response to the formal Information Request on June 30, 1999. The truthfulness, accuracy, and completeness of this information and the information submitted in the February 12, 1999 letter and attachments was certified as accurate on June 28, 1999, by David Suhr, Idle Properties Manager, Hecla Mining Company.
37. In the Hecla response, the Respondent stated that at the time of the Hecla purchase of the SGMC operation the following amounts of various materials are estimated to have been in the referenced ponds at the Site:

Pond	Contents	Estimated Amount
1A	not used	- -
1B	zinc sulfate	125 cu. yd.
1C	germanium operation waste	340 cu. yd.
2	leach tailings	56,800 cu. yd.
2A	leach tailings	23,272 cu. yd.
3A	iron sulfate	1,200 cu. yd.
3B north	iron sulfate	2,800 cu. yd.
3B south	iron sulfate	2,800 cu. yd.
surge pond	180 cu. yd.	

38. Hecla sampled the SGMC mineral beneficiation wastes in the ponds listed in paragraph 36 above in 1988 prior to purchase of the facility from SGMC. The results of the analyses were submitted to EPA in the February 12, 1999 submittal and certified as accurate on June 28, 1999 by the Respondent. The samples were analyzed using the EP toxicity method. The Pond 1C solids exceeded the EP regulatory limit for arsenic and cadmium; the Pond 2A solids exceeded the EP regulatory limit for arsenic, and the Pond 3A solids exceeded the EP regulatory limit for arsenic.
39. Hecla has asserted that Pond 1C was never used by Hecla, that Pond 2A contained SGMC tailings only and that Ponds 3B North and 3B South were not used by Hecla and contained only mineral beneficiation wastes from SGMC. Hecla has further asserted that Ponds 1A/B and 3A were the only ponds used for new waste disposal by Hecla after its purchase of the Site operation and lease.
40. In July 1995, Hecla began cleanup from its operations at the Site. Wastes from certain ponds were consolidated by Hecla into the Impoundment. An estimated 30,000 cubic yards from Pond 1A/B, an estimated 17,000 cubic yards from Pond 3A, and the volumes stated in paragraph 37 for Ponds 1C, 2A, and the surge pond were consolidated into the Impoundment. An unspecified amount of unmilled ore stockpiled at the Facility at the time the gallium and germanium operation was shut down in 1990 was also placed into the Impoundment.
41. The 1998 sample analyses indicated that the Pond 1C material from germanium operations exceeded EP toxicity levels for arsenic and cadmium, and the Pond 2A materials, leach tailings, exceeded EP toxicity levels for arsenic. The ponds were not used or the materials in them treated after being sampled in 1988 or prior to being excavated and consolidated into Pond 2 in 1995.
42. Excavated soils from the ore storage area, plant, Pond 3B North, and Pond 3B South were also placed into the Impoundment. These soils contained arsenic at concentrations up to 7000 parts per million ("ppm"), lead at concentrations up to 20,000 ppm, cadmium at concentrations up to 640 ppm, and chromium at concentrations up to 380 ppm.

43. During years of operation, per Attachment J, Information Request Response No. 5, submitted in response to EPA's January 15, 1999 Information Request, "Ore Sources from the Mine During the GA/GE Operations, the Apex Mine ore reserves contained 0.44 to 1.53 percentage of arsenic." In the February 12, 1999 response, Respondent indicated that when the gallium and germanium operation was shutdown in 1990, unmilled ore at the facility was placed into Pond 2 during cleanup. This material was not characterized or treated prior to disposal in Pond 2.
44. Hecla's February 12, 1999, response indicates that the acidic pond liquids remaining from the SGMC mining activities in Ponds 1C, 3B North and 3B South were neutralized with limestone and lime prior to relocation of the waste.
45. The Impoundment was capped with soil obtained from construction of ponds 3B and 3C. This cover had a crown to promote runoff when first placed on the Impoundment, but over time the cover has settled into a flat cover with localized depressions in which precipitation may pond. Leachate from the Impoundment is collected from the wet waste materials by the weight of the soil cap squeezing the waste liquids out of the Impoundment into a small lined trench immediately adjacent to the Impoundment solids along its down gradient edge. The trench flows into a small lined evaporation pond. The liner for both the trench and evaporation pond is UV resistant PVC.
46. During the site inspection on November 16, 1998, the evaporation pond was full and there was standing water adjacent to the pond and the collection trench. There was little to no freeboard in the pond and trench. The berms of the collection ditch and evaporation pond needed repair.
47. During the site inspection on November 16, 1998, EPA Inspectors observed seepage of liquids on the northeast side of the Impoundment. The seepage had formed white crystals on the surface of the soil which Hecla tested and determined to be benign. A liquid sample from this seep area was found to contain low levels of all RCRA metals, and slightly exceeded the level of 5 ppm for arsenic.
48. The November 1998 EPA samples were collected at five locations at or near the Site: 1) the pond water adjacent to the lined ditch, 2) the lined ditch, 3) the Hecla evaporation pond, 4) the "seep" area on the east side of the Impoundment, and 5) surface water from the catchment basin. The sample results detected various metals and chemicals commonly associated with mineral beneficiation, including arsenic, barium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, tungsten, and ammonia.
49. The analytical results for the EPA sample collected in November 1998 for the liquid sample collected from the seep area on the east side of the Impoundment detected arsenic at 5.82 ppm. Hecla's own analytical results detected arsenic in the liquid, when analyzed for dissolved metals, at 5.9 ppm.
50. Based on the information submitted and the analytical results, EPA has concluded that the Respondent has managed solid waste at the Facility in such a manner that releases to the

environment have occurred at and from the Facility.

Effects on Human Health or the Environment:

51. Hazardous constituents detected in EPA and/or Hecla samples include arsenic, barium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, tungsten, and ammonia. EPA has determined that the following are effects on human health or the environment that may be caused by the constituents detected:

- i. **Arsenic:** Arsenic is a known carcinogen, and a potential teratogenic agent. Its main path of exposure to humans is through inhalation and dermal absorption. Long term exposure can cause nerve and liver damage, narrowing of the blood vessels, and affect red blood cell production. Arsenic in the presence of acid may release a deadly gas, arsine. Arsenic has high acute toxicity to aquatic life, birds and land animals. It has a low solubility in water and is persistent in water, with a half-life of 200 days. Arsenic has high chronic toxicity to aquatic life, and is known to bioaccumulate in fish tissues.
- ii. **Cadmium:** High exposure to cadmium can cause acute health effects such as severe lung damage, fluid in the lungs, and in severe cases death. Cadmium is a probable cancer causing agent in humans, some studies link it to kidney and prostate cancer in humans, and it has been shown to cause lung and testes cancer in animals. It is a probable teratogen in humans, and may also damage the testes and affect the female reproductive cycle. Repeated low exposure can cause permanent kidney damage. Cadmium is highly persistent in water, with a half-life of greater than 200 days. Cadmium toxicity is influenced by water hardness, the harder the water the lower the toxicity. It has chronic and acute toxicity to aquatic life.
- iii. **Chromium:** Acute exposure to chromium dust can cause "metal fume fever", which causes fevers, chills, and muscle aches. Chromium is highly persistent in water and has a half-life of greater than 200 days. Hexavalent chromium is soluble and more mobile in groundwater than the trivalent chromium. Hexavalent chromium has a high acute and chronic toxicity to aquatic life.
- iv. **Cobalt:** Cobalt compounds may cause mutations in living cells, although it is not clear whether it is carcinogenic. Cobalt can damage the heart, causing heart failure. Long term exposure may damage the thyroid and liver. Repeated exposure can cause scarring of the lungs. Cobalt and its salts have high acute toxicity to aquatic life.

Lead: Lead is a probable teratogen in humans. The primary routes of exposure are through inhalation and ingestion. Chronic health effects include decreased fertility in male and females; kidney and brain damage. Chronic lead exposure causes nerve and behavioral effects in humans and could cause similar effects in birds and animals. Water hardness controls the toxicity of

lead to aquatic life, the softer the water the greater the toxicity. It has a high chronic toxicity to aquatic life.

Mercury: Exposure to high levels can cause pulmonary edema and death. Mercury compounds are human teratogens and may be embryotoxic. Chronic exposure can lead to kidney and damage. Acute and chronic exposure can lead to tremors, loss of memory, hallucinations and psychosis. Mercury (II) and methyl mercury have high acute and chronic toxicity to aquatic life.

Nickel: Nickel is a probable human carcinogen and may damage the developing fetus. High exposure through inhalation can lead to pulmonary edema and death. It can cause damage to the lungs, heart, liver and/or kidney. Nickel and its compounds have a high acute and chronic toxicity to aquatic life.

Selenium: There are generally three types of selenium toxicity: acute selenosis, subacute selenosis and chronic selenosis. The acute condition results in unsteady walking, labored breathing, liver congestion, degeneration of the gastrointestinal tract, gallbladder and bladder, and erosion of the long bones. Subacute selenosis results in neurological dysfunction, including impaired vision, ataxia, disorientation, and respiratory distress. In grazing livestock, it is referred to as "blind stragglers". Chronic selenosis results in skin lesions, emaciation, hoof necrosis and loss in animals. In humans, chronic selenosis is characterized by fatigue, anorexia, gastroenteritis, enlarged spleen, and hepatic degeneration.

Silver: The critical effect in humans ingesting silver is argyria, a permanent bluish-gray discoloration of the skin. Hepatic necrosis and ultrastructural changes of the liver have been induced by silver administration to vitamin E and/or selenium deficient rats.

V. CONCLUSIONS OF LAW

52. Respondent is a "person" as defined in Section 1004(15) of RCRA, 42 U.S.C. 6903(15).
53. Respondent has handled "solid waste" within the meaning of Section 1004(27) of the Act, 42 U.S.C. § 6903(27).
54. Respondent has contributed and/or is contributing to the handling, storage, treatment, transportation or disposal of solid waste at the Site within the meaning of Section 7003 of RCRA, 42 U.S.C § 6973.
55. Respondent's contribution of solid waste to and/or handling of solid waste at the Site may currently present an imminent and substantial endangerment to health or the environment within the meaning of Section 7003.

VI. ORDER

56. Based on the above and on other information contained in the administrative record for this Consent Order, EPA has determined that the activities required by this Consent Order (the "Work") are necessary to protect health or the environment. Respondent agrees to perform the Work specified in this Consent Order in the manner and by the dates specified herein. All Work undertaken pursuant to this Consent Order shall be performed in a manner consistent with this Consent Order, including all documents incorporated herein pursuant to this Consent Order, and all applicable laws.

VII. WORK TO BE PERFORMED

57. Respondent shall plan, implement, perform, and complete all actions required by this Consent Order in accordance with the standards, criteria, specifications, requirements, and schedules set forth herein, including schedules set forth in work plans submitted pursuant to this Consent Order, or as modified by mutual written agreement between the parties.
58. Within fifteen (15) calendar days of the effective date of this Consent Order, Respondent shall post signs along the perimeter of the Impoundment stating "Danger - Solid Waste Impoundment - Unauthorized Personnel Keep Out. This Area May Be Dangerous to Human Health." These signs must be legible from a distance of at least twenty-five (25) feet from each sign and in both English and Spanish. The perimeter signs shall be placed at a maximum spacing of 200 feet around the perimeter of the Impoundment.
59. In order to restrict unauthorized access to the Impoundment, Respondent shall ensure that the fence located around the perimeter of the Impoundment is locked at all times except when it is necessary to perform work pursuant to this Order, or to add or remove materials to or from the Impoundment.
60. Pursuant to the 3013 Order, Respondent was ordered to submit a written proposal to EPA for carrying out monitoring, testing, analysis, and reporting to ascertain the nature and extent of the hazard posed by any hazardous wastes that are present at or that may have been released from the Respondent's Facility. Without waiving its right to contest EPA's assertion that hazardous waste is present at or has been released from its Facility, Respondent submitted such a proposal on January 20, 2000.
61. The Respondent submitted a Revised Soils Sampling and Analysis Workplan ("Revised Workplan") to EPA on August 31, 2000, based on EPA comments to the January 20, 2000 proposal. EPA approved the Revised Workplan on September 24, 2001.
62. The Respondent conducted an investigation of the Impoundment in accordance with the Revised Workplan beginning October 1 through October 3, 2001. All laboratory testing was completed by November 16, 2001. The results of the investigation are set forth in a

document provided by the Respondent to EPA on December 3, 2001, entitled "Results of October 2001 investigations; Apex Site Pond 2 Soils Sampling and Analysis." (the "October 2001 Report").

63. The October 2001 Report sets forth a conceptual Closure Work Plan based on a conclusion that no seepage migration from the Impoundment into the soil could be identified. (Attachment A).
64. Within forty-five (45) days of Hecla's receipt of notice of the filing of this Consent Order with the EPA Regional Judicial Officer, Respondent shall begin to implement the EPA-approved Closure Work Plan attached to this Consent Order as Attachment A.
65. Respondent shall submit a written progress report to EPA concerning actions undertaken pursuant to the Consent Order. Upon the effective date of this Consent Order, progress reports for each month's activities will be due on the 28th day of the following month. The requirement to submit progress reports will continue until all tasks required by the Consent Order have been completed. These reports shall include the following information: a) activities accomplished and progress made during the reporting period; b) problems and resolved solutions; c) sampling/laboratory activities, samples collection, analyses requested, and analytical results received; d) personnel or schedule changes; e) activities planned for the next reporting period; and f) estimated or actual costs for the activities planned.
66. Within thirty (30) days of the completion of all tasks required by the Closure Work Plan, Respondent shall submit for EPA review and approval a Completion Report summarizing the actions taken to comply with the Closure Work Plan. The Completion Report shall have accompanying appendices containing all relevant documentation generated, including analytical data, waste determinations, manifests, engineering designs, invoices or purchase orders, bills, contracts, receipts, and canceled checks.
67. The Closure Work Plan and all reports or documents required to be submitted under this Consent Order shall be mailed to the following EPA representatives:

Eric Johnson
U.S. Environmental Protection Agency Region 8
8ENF-T999 18th Street, Suite 300
Denver, CO 80202-2466

Copies of the written proposal and all reports or documents required to be submitted under this Consent Order shall be simultaneously mailed to the following Tribal and BIA representatives:

Glenn Rogers, Chairman
Shivwits Band of Paiute Indian Tribe
P.O. Box 448
Santa Clara, UT 84765

John Krause
Bureau of Indian Affairs
Phoenix Area Office
U.S. Department of Interior
P.O. Box 10
Phoenix, AZ 85001

Deborah Hamlin
BIA Southern Paiute Field Station
Branch of Natural Resources
P.O. Box 720
St. George, UT 84771

VIII. DISPUTE RESOLUTION

68. If Respondent disagrees, in whole or in part, with any EPA disapproval or other decision or directive made by EPA pursuant to this Order, Respondent shall notify EPA in writing of its objections, the basis for its position, and any matters which it considers necessary for determination, within fourteen (14) days of receipt of EPA's disapproval, partial approval, decision, or directive. EPA and Respondent shall then negotiate in good faith and will have an additional fourteen (14) days from EPA's receipt of Respondent's objections to attempt to resolve the dispute. If agreement is reached, the resolution shall be reduced to writing, signed by representatives of each party and incorporated into this Order. If the parties are unable to reach agreement within this fourteen (14) day period, Respondent may request mediation of the dispute employing a mediator based in Denver, Colorado acceptable to both parties, and/or Respondent and EPA may submit additional written information to the Assistant Regional Administrator, Office of Enforcement, Compliance, and Environmental Justice, EPA Region 8. EPA will maintain a record of the dispute, which will contain all statements of position and any other documentation, submitted pursuant to this section. EPA will allow timely submission of relevant supplemental statements of position by the parties to the dispute. Based on the record, EPA will respond to Respondent's arguments and evidence and provide Respondent with EPA's written decision on the dispute signed by the EPA Region 8 Assistant Regional Administrator, Office of Enforcement, Compliance, and Environmental Justice.
69. Any agreement or decision made pursuant to this section by EPA shall be reduced to writing, shall be deemed incorporated into this Consent Order without further order or process, and shall be binding on the parties. If the United States brings an action to enforce any such decision, Respondent has and reserves the right to raise any defenses it would otherwise be permitted to raise under applicable principles of administrative law.
70. Stipulated penalties may not be assessed for alleged non-compliance with requirements of this Order which are the subject of dispute resolution during the pendency of such proceedings hereunder.

IX. SUBMISSIONS/AGENCY REVIEW

71. EPA will review all plans, reports, or other submittals required under this Consent Order, using its best efforts to complete such review within forty-five (45) days of their receipt by EPA. EPA may: (a) approve the submission; or (b) approve the submission with modifications; (c) disapprove the submission and direct Respondent to re-submit the document after incorporating EPA's comments; or (d) disapprove the submission and assume responsibility for performing all or any part of the work. As used in this Consent Order, the terms "approval by EPA," "EPA approval," or a similar term means the action described in (a) or (b) of this paragraph.
72. Prior to approval in writing, or approval with modifications in writing, no plan, report, or other submittal shall be construed as approved and final. Oral advice, suggestions, or comments given by EPA representatives will not constitute approval, nor shall any oral approval or oral assurance of approval be considered as binding.
73. Upon receipt of a notice of disapproval in paragraph 72(c) above or a request for a modification, Respondent shall, within thirty (30) days, or such longer time as specified by EPA in its notice of disapproval or request for modification, correct the deficiencies and resubmit the plan, report, schedule, other item for approval. Notwithstanding the notice of disapproval, or approval with modifications, Respondent shall proceed, at the written direction of EPA, to take any action required by any non-deficient portion of the submission.
74. All plans, reports, and/or other submittals required by this Consent Order are, upon approval or approval with modifications by EPA not inconsistent with the approved Closure Work Plan, incorporated into this Consent Order as if fully set forth in the text herein. Any noncompliance with such EPA-approved plans, reports, specifications, schedules, and attachments shall be noncompliance with this Consent Order. Oral advice or approvals given by EPA representatives shall not relieve Respondent of its obligation to obtain any formal, written approvals required by this Consent Order.
75. In all instances which this Consent Order requires written submissions to EPA, each submission must be accompanied by the following certification signed by a "responsible official":

Under penalty of law, I certify to the best of my knowledge, information, and belief, after appropriate inquiries of all relevant persons involved in the preparation of this submission and in reliance upon the information provided to me by such persons, that the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment for knowing violations.

For the purpose of this certification, a "responsible official" means a person in charge of a

principal facility function, or any other person who performs similar decision-making functions for the facility.

X. PROJECT COORDINATORS

76. EPA hereby designates as its Project Coordinator:
Eric Johnson
U.S. Environmental Protection Agency Region 8
8ENF-T999 18th Street, Suite 300
Denver, CO 80202-2466
77. Respondent hereby designates as its Project Coordinator:
Chris C. Gypton
Hecla Mining Company
6500 N. Mineral Drive, Suite 200
Coeur d'Alene, ID 83815-9408
78. Each Project Coordinator shall, on behalf of the party that designated that Project Coordinator, oversee the implementation of this Consent Order and function as the principal project contact.
79. Respondent shall provide EPA with a written notice of any change in its Project Coordinator. Such notice shall be provided as soon as practicable.

XI. THREATS TO PUBLIC HEALTH OR THE ENVIRONMENT

80. If EPA determines that activities in compliance or noncompliance with this Consent Order have caused or may cause a release of hazardous waste or hazardous constituents, that may present an imminent and substantial endangerment to the public health or to the environment, EPA may require that Respondent stop further implementation of this Consent Order for such a period of time as may be needed to (1) abate any such release or threat of release and/or (2) undertake any action which EPA determines is necessary to abate such release ; and may thereafter require Respondent to resume implementation of this Consent Order.

XII. SAMPLING AND DOCUMENT AVAILABILITY

81. Respondent shall submit to EPA upon request, the results of all sampling and/or tests or other data generated by, or on behalf of, the Respondent in implementing the requirements of this Consent Order.

XIII. ACCESS

82. Respondent shall provide access at all reasonable times to the facility, subject to the consent of the Tribe where access to the Tribe's land is necessary, and to all records and documentation relating to conditions at the facility and the activities conducted pursuant to this Consent Order to EPA and its employees, contractors, agents, consultants, and representatives. These individuals shall be permitted to move freely at the facility in order to conduct activities which EPA determines to be necessary. Operations requiring the use of heavy equipment, such as intrusive sampling of the Impoundment, may be completed only after discussion with Hecla concerning appropriate safety and logistics for such operations and Hecla approval of specific procedures for such operations.
83. To the extent that activities required by this Consent Order, or by any approved work plans prepared pursuant hereto, must be done on property not owned or controlled by Respondent, Respondent will use its best efforts to obtain site access agreements in a timely manner from the present owners of such property. Best efforts as used in this paragraph shall include the payment of reasonable compensation in consideration of granting access. Respondent shall ensure that EPA's Project Coordinator has a copy of any access agreements.
84. Nothing in this Consent Order limits or otherwise affects EPA's right of access and entry pursuant to applicable law, including RCRA and the Comprehensive Environmental Response, Compensation and Liability Act.
85. Respondent shall notify the EPA, Tribal and BIA representatives identified in paragraphs 67 and 68 in writing at least ten (10) calendar days before engaging in any field activities at the facility, including but not limited to sampling, remediation, well-drilling, and installation of equipment. Respondent shall allow EPA, Tribal or BIA representatives to be on-site at the time of any field activities, provided such representatives comply with EPA-approved health and safety plan(s) for the Work.
86. At the request of EPA, Respondent shall provide or allow EPA or its authorized representatives to take split and/or duplicate samples of all samples collected by Respondent pursuant to this Consent Order, provided such representatives have their own sample container and preservatives, and take immediate custody of such split and/or duplicate samples, and provided that there is sufficient sample volume available to obtain a split and/or duplicate sample.

XIV. RECORD PRESERVATION

87. Respondent shall retain, during the pendency of this Consent Order and for a minimum of five (5) years after its termination, a copy of all data, records, and documents now in its possession or control, or in the possession or control of its contractors, subcontractors, representatives, or which come into the possession or control of the Respondent, its contractors, subcontractors, or representatives, which relate in any way to this Consent

Order. Respondent shall notify EPA, in writing, at least ninety (90) days in advance of the destruction of any such records, and shall provide EPA with the opportunity to take possession of any such records not otherwise privileged from disclosure. Such written notification shall reference the caption, docket number and date of issuance of this Consent Order and shall be addressed to:

Sharon Kercher, Director
Technical Enforcement Program
U.S. EPA Region 8
8ENF-T999 18th Street, Suite 500
Denver, CO 80202-2466

In addition, Respondent shall provide data, records and documents retained under this Section at any time before the expiration of the five-year period at the written request of EPA.

XV. INFORMATION SUBMITTED TO EPA

88. Any information that Respondent is required to provide or maintain pursuant to this Consent Order is not subject to the Paperwork Reduction Act of 1995, 44 U.S.C. § 3501 et seq.
89. Respondent may assert a business confidentiality claim in the manner described in 40 C.F.R § 2.203(b) covering all or part of any information submitted to EPA pursuant to this Consent Order. Any assertion of confidentiality shall be adequately substantiated by Respondent when the assertion is made in accordance with 40 C.F.R § 2.204(e)(4). Information submitted for which Respondent has asserted a claim of confidentiality as specified above shall be disclosed by EPA only to the extent and manner permitted by 40 C.F.R Part 2, Subpart B. If no such confidentiality claim accompanies the information when it is submitted to EPA, it may be made available to the public by EPA without further notice to the Respondent.

XVI. RESERVATION OF RIGHTS

90. The parties agree that "additional work" or "additional tasks" for purposes of this Order shall be limited to only those problems or tasks sufficiently related to or resulting from performance with the Order or closure work plan. EPA expressly reserves all rights and defenses that it may have, including the right both to disapprove of work performed by Respondent pursuant to this Consent Order, and to separately order that Respondent perform additional tasks not sufficiently related to or resulting from performance with the Order or closure work plan pursuant to its authority under applicable law.
91. Nothing in this Consent Order shall limit the information gathering, access, and response authority of the United States under any other applicable law, nor shall it limit the authority of EPA to issue additional orders to Respondent as may be necessary. Nothing

herein shall limit the power and authority of EPA to take, direct, or order all actions necessary to protect public health, welfare, or the environment or to prevent, abate, or minimize an actual or threatened release of hazardous substances, pollutants or contaminants, or hazardous or solid waste on, at, or from the facility. Further, nothing herein shall prevent EPA from seeking legal or equitable relief to enforce the terms of this Consent Order, from taking other legal or equitable action as it deems appropriate and necessary, or from requiring the Respondent in the future to perform additional activities pursuant to Section 3008(h) of RCRA, 42 U.S.C. § 6928(h), or any other applicable law. Nothing, other than the agreed upon terms of this Consent Order, shall preclude the Respondent from exercising any of its rights under the law.

92. This Consent Order shall not be construed as a waiver or limitation of any rights, remedies, powers and/or authorities which EPA has under RCRA or any other applicable law.
93. EPA hereby reserves all of its statutory and regulatory powers, authorities, rights, remedies, both legal and equitable, which may pertain to any failure of Respondent to comply with any applicable laws and regulations and with any of the requirements of this Order, including but not limited to, the right to disapprove of work performed by Respondent, to request that Respondent perform additional tasks, and the right to perform any portion of the work herein.
94. Hecla hereby reserves all of its defenses, including but not limited to those relating to whether an imminent and substantial threat to human health and the environment may exist at the Site, whether the waste and other materials at issue in this proceeding constitute hazardous wastes under subtitle C of RCRA, and whether EPA may require additional work be performed by Hecla at the Site not required by or consistent with the Closure Work Plan.

XVII. FORCE MAJEURE

95. Respondent agrees to perform all requirements under this Consent Order within the time limits established under this Consent Order, unless the performance is delayed by a force majeure event. For purposes of this Consent Order, a force majeure event is defined as any event arising from causes beyond the control of Respondent or of any entity controlled by the Respondent, including but not limited to their contractors and subcontractors, that delays or prevents performance of any obligation under this Consent Order despite Respondent's best efforts to fulfill the obligation. Force majeure does not include financial inability to complete the work or increased cost of performance. Nothing in this Consent Order precludes the parties from extending any of the time frames by mutual agreement; however, such agreement must be memorialized in writing prior to the due dates.
96. Respondent shall notify EPA orally within 24 hours after the event, and in writing within five days after Respondent becomes or should have become aware of events which constitute a force majeure event. Such notice shall: identify the event causing the delay

or anticipated delay; estimate the anticipated length of delay, including necessary demobilization and re-mobilization; state the measures taken or to be taken to minimize the delay; and estimate the timetable for implementation of the measures. Respondent shall take all reasonable measures to avoid and minimize the delay. Failure to comply with the notice provision of this Section shall waive any claim of force majeure by Respondent.

97. If EPA determines a delay in performance of a requirement under this Consent Order is or was attributable to a force majeure event, the time period for performance of that requirement shall be extended as deemed necessary by EPA. Such an extension shall not alter Respondent's obligation to perform or complete other tasks required by the Consent Order which are not directly affected by the force majeure event.

XVIII. PUBLIC COMMENT

98. Pursuant to Section 7003(d) of RCRA, 42 U.S.C. § 6973(d), EPA will announce the availability of this Consent Order to the public for review and comment. EPA will accept comments from the public for a period of thirty (30) calendar days after such announcement. If sufficient interest warrants, as determined by EPA, a public meeting will be held. At the end of the comment period, EPA will review all comments received during the comment period and/or at any public meeting. EPA will forward to Respondent a copy of all such comments and EPA's written response to such comments, whereupon Respondent shall have seven (7) days to submit a response to EPA. EPA shall then either:
- i. Determine that the Consent Order should be made finally effective in its present form, and entered with the Regional Hearing Clerk, in which case Respondent shall be notified; or
 - ii. Determine that modification of the Consent Order is necessary, in which case Respondent shall be informed as to the nature of all required changes. If Respondent agrees to the modifications, the Consent Order shall be so modified, signed by the parties, and entered with the Regional Hearing Clerk.

XIX. OTHER APPLICABLE LAWS

99. All actions required to be taken pursuant to this Consent Order shall be undertaken in accordance with the requirements of all applicable federal, tribal, and local laws, regulations, permits, and ordinances.
100. Compliance by Respondent with the terms of this Consent Order shall not relieve Respondent of its obligations to comply with RCRA, or any other applicable federal, tribal, or local laws, regulations, permits, and ordinances.
101. This Consent Order is not and shall not be interpreted to be a permit, or as a ruling or a

determination of any issue related to a permit under federal, tribal or local law. This Consent Order shall not in any way affect Respondent's obligation, if any, to secure such a permit, nor shall this Consent Order be interpreted in any way to affect or waive any of the conditions or requirements that may be imposed as conditions of such permit or of Respondent's right to appeal any conditions of such permit. Respondent shall obtain or cause its representatives to obtain all permits and approvals necessary under such laws and regulations.

XX. OTHER CLAIMS

102. Nothing in this Consent Order shall constitute or be construed as a release from any claim, cause of action, demand, or defense in law or equity, against any person, firm, partnership, or corporation for any liability it may have arising out of or relating in any way to the generation, storage, treatment, handling, transportation, release, or disposal of any hazardous waste constituents, hazardous substances, hazardous wastes, pollutants, or contaminants found at, taken to, or migrating from the facility.
103. By issuance of this Consent Order, the United States and EPA assume no liability for injuries or damages to persons or property resulting from any acts of omissions of Respondent or its agents, contractors, subcontractors or other representatives.
104. Neither the United States nor EPA shall be a party or be held out as a party to any contract entered into by the Respondent or its directors, officers, employees, agents, successors, representatives, assigns, contractors, or consultants in carrying out activities pursuant to this Consent Order.

XXI. SUBSEQUENT MODIFICATION OF CONSENT ORDER

105. Except as provided in paragraph 108, this Consent Order may only be modified by written amendment signed by EPA Region VIII Technical and Legal Enforcement Supervisors.
106. Modifications to any schedule adopted pursuant to this Consent Order may be made in writing by EPA, subject to agreement by Respondent or dispute resolution hereunder with respect to such schedule change(s).
107. No informal advice, guidance, suggestions, or comments by EPA shall be construed to modify the requirements of this Consent Order. Routine communications exchanged verbally, in person, by telephone or by electronic mail, between the parties to facilitate the orderly conduct of work contemplated by this Consent Order shall not alter or waive any rights and/or obligations of the parties under this Consent Order.

XXII. STATEMENT OF SEVERABILITY

108. If any provision or authority of this Consent Order, or the application of this Consent

Order to any party or circumstances, is held by any judicial or administrative authority to be invalid, the application of such provisions to other Parties or circumstances and the remainder of the Consent Order shall not be affected thereby.

XXIII. TERMINATION AND SATISFACTION

109. Respondent may seek termination of this Consent Order by submitting to EPA a written document which indicates Respondent's compliance with all requirements of this Consent Order, and the associated dates of approval correspondence from EPA. The provisions of this Consent Order shall be deemed satisfied upon Respondent's and EPA's execution of an "Acknowledgment of Termination and Agreement for Record Preservation and Reservation of Rights" (Acknowledgment). The Acknowledgment shall specify that Respondent has demonstrated to the satisfaction of EPA that the terms of this Consent Order, including any additional tasks determined by EPA to be required pursuant to this Consent Order, have been satisfactorily completed.
110. The provisions of this Consent Order shall be deemed satisfied upon Respondent's receipt of written notice from EPA that Respondent has demonstrated to the satisfaction of EPA that the terms of the Consent Order, including any additional tasks determined by EPA to be required pursuant to this Consent Order and which are agreed to by Respondent, have been satisfactorily completed. This notice shall not, however, terminate Respondent's obligations to comply with any continuing obligations hereunder, including without limitation, Section XIV (Record Preservation) and Section XIX (Other Applicable Laws).

XXIV. FAILURE TO COMPLY

111. For each day, or portion thereof, that Respondent fails to perform fully any requirement of the Consent Order in accordance with the schedule established pursuant to the Order, Respondent shall be liable as follows:
 - A. For failure to submit an amended Closure Work Plan or the Completion Report, Respondent shall pay a stipulated penalty of \$500 per document for each late day until the documents are submitted.
 - B. For failure to submit a progress report, Respondent shall pay a stipulated penalty of \$250 for each monthly report.
 - iii. For failure to provide the notification required in this Consent Order, Respondent shall pay a stipulated penalty of \$500 for each day the notification is late.
 - iv. For "work" that has not been completed as required by the Closure Work Plan, Respondent shall pay a stipulated penalty of \$250 for each day such failure remains uncured.

Stipulated penalties shall begin to accrue on the day after performance is due and shall continue to accrue through the final day of the completion of the activity.

Respondent shall pay stipulated penalties within fifteen (15) days of receipt of written demand by EPA for such penalties, unless Respondent invokes dispute resolution hereunder with respect to the event giving rise to such stipulated penalties.

Respondent shall pay stipulated penalties by submitting a cashier's or certified check, to the order of the "treasurer, United States of America," to:

U.S. EPA, Region 8(Regional Hearing Clerk)
P.O. Box 360859M
Pittsburgh, PA 15251

Respondent shall provide copies of the checks to:

Regional Hearing Clerk
U.S. EPA
Region 8999 18th Street, Suite 300
Denver, CO 80202-2466

and

Amy Swanson
8ENF-LLegal Enforcement Program
U.S. EPA
Region 8999 18th Street, Suite 300
Denver, CO 80202-2466

Pursuant to 31 U.S.C. § 3717, EPA is entitled to assess interest and penalties on debts owed to the United States and a charge to cover the cost of processing and handling a delinquent claim. Interest will therefore begin to accrue on a civil or stipulated penalty if it is not paid by the last date required.

Treasury tax and loan rate is in accordance with 4 C.F.R. § 102.13(c). A charge will be assessed to cover the costs of debt collection, including processing and handling costs and attorney's fees. In addition, a penalty charge of twelve (12) percent per year compounded annually will be assessed on any portion of the debt which remains delinquent more than ninety (90) days after payment is due. Any such penalty charge on the debt will accrue from the date the penalty payment becomes due and is not paid in accordance with 4 C.F.R. § 102.13(d) and (e).

XXV. EFFECTIVE DATE

112. The effective date of this Consent Order shall be the date of filing with the Regional Judicial Officer.
113. Modifications made by EPA to this Consent Order are effective on the date such modification is received by the Respondent, and after it is filed with the Region Hearing Clerk.

SO AGREED TO BY THE PARTIES,

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 8
Complainant.**

By: _____
Michael T. Risner, Director
David J. Janik, Supervisory Enforcement Attorney
Legal Enforcement Program
Office of Enforcement, Compliance
and Environmental Justice

Date: _____

By: _____
Sharon L. Kercher, Director
Technical Enforcement Program
Office of Enforcement, Compliance
and Environmental Justice

Date: _____

**HECLA MINING COMPANY
Respondent.**

By: PSB
Phillips S. Baker, Jr.
Print Name
President and CEO
Title

Date: September 01, 2004



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 8
999 18TH STREET - SUITE 300
DENVER, CO 80202-2466
Phone 800-227-8917
<http://www.epa.gov/region08>

July 7, 2004

Ref: 8ENF-L

SENT VIA FACSIMILE AND REGULAR MAIL

Chris Gypton, Project Manager-Senior Engineer
Hecla Mining Company
6500 Mineral Drive, Suite 200
Coeur d'Alene, ID 83815-9498

Re: Hecla Mining Co., Docket No. RCRA-8-99-06
Final Closure Work Plan Approval

Dear Mr. Gypton:

The Environmental Protection Agency Region 8 (EPA) hereby approves the final closure work plan for the Apex Site Pond 2, submitted to EPA by Hecla Mining Company on March 25, 2004. This document shall be attached to and referenced as Attachment A, Closure Work Plan, in the administrative order on consent to be entered into by Hecla and EPA in the above-cited matter, pursuant to section 7003 of the Resource Conservation and Recovery Act, 42 U.S.C. § 6973. EPA's approval is based on review of the draft final closure work plan, review and comment on the initial draft closure work plan document, dated August 17, 2003, and a comprehensive investigation and analysis of Pond 2 beginning with EPA's initial inspection of Pond 2 in 1998. EPA coordinated with the Paiute Indian Tribe and the Shivwits Band of Paiute Indian Tribe prior to approving the draft final closure work plan to the greatest extent practicable.

It is EPA's understanding that based on this approval, Hecla will commence with Phase 1 of the final closure construction activities, drainage and consolidation, on or about July 15, 2004. Please note that EPA's approval is not based on review and comment of the draft final closure work plan by the Bureau of Indian Affairs, Western Regional Office (BIA). BIA plans to retain a consultant to independently review and comment on the draft final closure work plan on its behalf. Any resulting comments or requests for clarification regarding the draft final closure work plan following BIA's review will be submitted to Hecla for consideration separate and apart from EPA's approval.

Please do not hesitate to write or call Eric Johnson, Environmental Scientist, if you have any questions. Mr. Johnson's telephone number is (303) 312-6357. His e-mail address is johnson.ericr@epa.gov.

Sincerely,

A handwritten signature in cursive script that reads "Sharon L. Kercher".

Sharon L. Kercher, Director
Technical Enforcement Program
Office of Enforcement, Compliance
and Environmental Justice

cc: Chris Gypton, Hecla Mining Co.
John N. Galbavy, Hecla Mining Co.
John R. Jacus, Esq., Davis, Graham & Stubbs
Glenn Rogers, Shivwits Band of Paiute
Tara Marlow, Paiute Tribe
Tod J. Smith, Whiteing & Smith
John Krause, BIA Western Regional Office

Apex Site

Final Engineering Report

for

Pond 2 Closure

Prepared for:

Hecla Mining Company
6500 Mineral Drive, Suite 200
Coeur d'Alene, Idaho 83815-8788

Prepared by:

Monster Engineering Incorporated
3031 Bonner Spring Ranch Road
Laporte, Colorado 80535

March 25, 2004



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1.0 INTRODUCTION

This report presents the Final Closure Plan for reclamation of Pond 2 at Hecla Mining Company's Apex Site near St. George, Utah. The closure plan, when implemented, is designed to provide for long-term hydraulic isolation of wastes currently contained in Pond 2 (the impoundment). Six closure plan alternatives were analyzed by Monster Engineering Inc. (MEI 2003a) and reviewed by Hecla prior to selection of a Selected Alternative for implementation. Details of the Selected Alternative, and one Modified Alternative, are presented as the Final Closure Plan in this document.

This Final Closure Plan is presented in two volumes. Volume I (this volume) is organized in five sections, including this Introduction section, that describe and summarize the closure plan, along with all Tables, Figures and the Appendices. Section 2.0 describes site background, and includes summaries of previously conducted waste material sampling and analysis, and the potential borrow material investigation. Additional waste material and field investigation information is included in Appendices A and B. Descriptions of the various closure alternatives examined, including Hecla's Selected Alternative, are presented in Section 3.0, Closure Alternatives. Section 4.0 presents the estimated construction sequencing and Section 5.0 summarizes design analyses for the Selected Alternative. Section 6.0. provides a construction cost estimate. Tables and Figures referenced in each section are presented at the end of the report. Complete analyses for the Selected Alternative are included in Appendices C through F. Estimated construction costs, the Monitoring and Maintenance Plan, and the Quality Control Plan are included in Appendices G, H, and I, respectively. Volume II of this plan contains the Final Plan Specifications and Drawings.

2.0 SITE BACKGROUND

The Apex Site is located approximately 15 miles northwest of St. George, Utah (Figure 1) on land leased from the Shivwits Band of the Paiute Tribe. The project location is shown on Figure 2. Pond 2 (the impoundment) is a synthetically-lined waste containment facility approximately 500 feet in diameter and 15 feet deep (SMI 2001). The current bottom liner consists of a fabric-reinforced spray-on asphaltic membrane approximately one-quarter to one-half inch in thickness. Hecla removed and disposed of a variety of on-site materials into Pond 2 as part of a site cleanup agreement with OMG in 1995. Materials currently in the impoundment include:

- gallium and germanium extraction process wastes (solutions and solids)
- cobalt-sulfate recovery process wastes
- ore stockpile materials
- old impoundment liner materials
- subsoils

Some of these materials were mixed with lime and limestone prior to disposal, while others were dredged and pumped into the impoundment as a slurry. During site cleanup work, the perimeter embankment was raised approximately five feet to provide sufficient capacity for waste material disposal. The embankment raise was constructed utilizing on-site soils (clay to cobble sizes) over the centerline of the existing embankment. The raise was unlined and the crest is approximately 10 feet wide. The embankment ranges from three feet to seven feet above the existing ground surface with outslopes that range from approximately 2:1 (H:V) to 3:1. Currently the impoundment has a temporary cover which is approximately two to four and one-half feet thick. It was constructed of a combination of on-site materials ranging from rock to topsoil. After completion of the temporary cover several seepage areas developed through and at the outside face of the unlined embankment raise. Figures 3 and 4 show the plan view and two profiles of the current impoundment configuration. Information provided in Figures 3 and 4 was collected by Hecla during prior reclamation activities (SMI 2001 and Hecla 2001) and field investigations. These prior field investigations are discussed in Sections 2.1 and 2.2.

The impoundment is underlain by up to 30 feet of aeolian and colluvial soils, primarily silty sands. Beneath these soils are a sequence of sandstones, siltstones, and limestones several hundred feet thick. Groundwater levels have been measured at depths from 160 to 300 feet (SMI 2001).

The Apex Site is located in a very arid region, averaging between 8.3 and 12.5 inches of precipitation annually. Surface water drainage at the site area is in general from south to north. All current upgradient runoff is diverted to the north on the east side of the impoundment by a small diversion channel. The limited quantity of runoff from the temporary cover (top surface of the impoundment) generally collects at the toe of the existing embankment in a separate broad flat collection ditch / basin. It appears that most, if not all

impoundment runoff remains in this basin, however some minor quantities may flow to the north around both sides of the impoundment.

During 2001 and 2002 Hecla completed two separate field investigations and laboratory analyses of the waste materials and potential borrow materials. Physical properties of representative materials were determined for utilization in the Final Closure Plan alternatives analyses.

2.1 Waste Material Sampling and Analysis

In October 2001 Hecla conducted a drilling, sampling, and laboratory testing program to determine the extent of, and potential for, seepage migration from the impoundment (Hecla 2001). Eight relatively undisturbed samples of waste materials from within the impoundment were successfully collected from depths ranging from five to nine feet below the top of the current surface. Wastes sampled were those from the last layer placed prior to temporary cover construction.

Moisture contents of the sampled waste materials ranged from 20% to 116% and in general increased with increasing depth and distance away from seepage areas. Seepage areas are shown on Figure 3. Additionally, the wastes were generally very fine grained with between 36 and 99 percent passing the #200 sieve. Laboratory permeability of the one tested sample was 3.7×10^{-6} cm/sec, indicating that seepage rates through the waste materials have been, and without assistance from installed drains, will continue to be very slow. All waste material laboratory test results are summarized in Appendix A.

The two known embankment seepage areas in general correlate with locations where coarser materials are known to have been placed during disposal and temporary cover placement activities. Profiles shown in Figure 4 show approximate waste material type locations (depths), sample locations, and sample moisture contents. As Hecla did not want to damage the bottom liner during drilling and sampling activities, and there is some uncertainty as to the actual liner elevation (depth), Material Types I through III were not sampled during the investigation. Therefore, moisture contents of material Types I through III are currently unknown. It is known that Material Type I included tailings and Material Type II included materials pumped into the impoundment as slurry (SMI 2001). Moisture contents of these materials may therefore be relatively high, although they have been and continue to be under much greater consolidation pressure than Material Type IV.

Two conclusions from the October 2001 materials investigation were:

- the collection ditch and evaporation ponds located on the southwest side of the impoundment are working properly and there is no evidence of seepage migration into soils outside the impoundment area near the southwestern seep or downgradient of the impoundment
- waste materials within the impoundment are very heterogeneous

2.2 Potential Borrow Source Materials Investigation

In November of 2002 Hecla conducted a potential borrow source materials investigation at and near the site to identify potential sources, available quantities, ownership, and index properties of suitable borrow materials (MEI 2003b). The physical properties of soils from these potential sources were utilized in the development of the Final Closure Plan alternatives.

Material properties of each layer in a cover system are critical to the long-term success of the overall cover (see Section 3.2 for general descriptions of cover systems and layer names). The Barrier Layer is the critical component of any cover system, therefore locating suitable materials for that layer was determined to be a key step in the design process. Suitable borrow materials were those which under optimum moisture and compaction conditions would exhibit a generally low permeability (1×10^{-6} to 1×10^{-8} cm/sec). The main conclusion from the field investigation was that several suitable low permeability borrow materials, in quantities sufficient to provide for a final cover for the impoundment, were located both near the site and on-site. Complete results from the field investigation and laboratory testing program are included in Appendix B.

3.0 CLOSURE ALTERNATIVES

Part of the process of implementing an effective and economic closure plan for Pond 2 included examining and analyzing three different waste drainage / consolidation methods and six different cover system alternatives. Analyses were conducted by Monster Engineering, Inc. (MEI 2003a) and reviews were completed by Hecla. One drainage / consolidation method and one cover system alternative were selected by Hecla as the Selected Alternative for this Final Closure Plan. Discussions regarding waste drainage / consolidation objectives, methods, and analyses, and the selected method are included in Section 3.1. Cover system background information, along with a summary of the different cover systems analyzed is included in Section 3.2. Details of the Selected Alternative's cover system are discussed included in Section 3.2.3. An additional cover system alternative (the Modified Alternative) was also selected by Hecla and is included in this plan (Section 3.2.4). The Modified Alternative was selected as a backup to allow Hecla some flexibility during the bidding and construction phase of the plan. In summary, the Modified Alternative consists of changing the Barrier Layer from a Geosynthetic Clay Liner (GCL) to a compacted clay liner (CCL). The CCL would be constructed with materials from a nearby native clay source (Blue Clay from the St. George area).

3.1 Waste Material Drainage and Consolidation

The primary objective of all cover systems is to provide for long-term hydraulic isolation of wastes. Too much differential or long-term consolidation after a cover system is completed can breach a cover system (EPA 1998). Therefore, a main factor in designing and constructing a successful cover system is to drain and consolidate wastes (and minimize future cover settlement) prior to cover system completion. Due to the physical characteristics of wastes within Pond 2, the potential for large differential and / or total long-term consolidation after placement of the cover system is significant. Waste characteristics include:

- high moisture contents
- high percentage of fines (very slow drainage)
- significantly varied material types and placement / disposal techniques
- relatively large consolidation force which will be applied by the final cover system
- potential continued seepage migration, similar to past seepage migration, towards the impoundment's unlined embankment raise

Relatively rapid and thorough drainage and consolidation of wastes prior to final cover placement should:

- remove and allow for evaporation of excess liquids currently within the wastes
- minimize overall and potentially large differential settlements after final cover completion
- minimize potentially expensive cover system repairs
- shorten the overall cover system construction period
- minimize hydraulic head on the existing bottom liner
- minimize future seepage towards and through the existing embankment and / or the tie-in between the cover system and existing liner

The drainage and consolidation methods reviewed and analyzed for the Closure Plan were in general based on three design criteria, which if implemented, would remove remaining free water from the wastes. (Hecla 2001). Those criteria were that the drainage system should:

- be passive and rely on gravity to convey flows
- incorporate existing evaporation ponds at the southwest embankment toe
- increase the consolidation rate of waste materials and removal of remaining free water

In order to meet the above criteria, three drainage and consolidation techniques were considered:

- (1) vertical wick drains
- (2) horizontal drains
- (3) no drains (weight of final cover only)

Hecla selected the vertical wick drain method based on analysis of the waste characteristics, the impoundment setting, overall cost, and potential effectiveness. In particular, the vertical wick drain method was selected because it could:

- be less time consuming to install versus horizontal drains
- provide for more thorough and timely drainage of all waste materials by providing the shortest drainage path - close spacing and uniform installation depth to reach all areas of the impoundment
- effectively reach most wastes - all areas of the impoundment can be easily reached from the surface
- be the most effective method of controlling and evaporating draining liquids by containing those liquids on top of the temporary cover - no additional collection ditches or evaporation ponds required and no additional pumping or monitoring required
- allow for quicker removal and disposal of existing Collection Ditch and Evaporation Pond materials
- allow for less complicated tie-in construction between the existing bottom liner and the new (GCL) top liner
- allow for more efficient construction sequencing
- more effectively reduce hydraulic head on the existing bottom liner

3.2 Cover Systems

3.2.1 Background Information

Cover systems can range from a one-layered vegetated soil to a complex multi-layer approach utilizing soils and geosynthetics (EPA 1998). Their effectiveness is primarily a function of the attention given to quality in choosing, installing, and inspecting each layers' materials and placement techniques (Daniel 1995a). Covers are also most effective where wastes are placed above the groundwater table, as is the case for Pond 2. In general, less complex systems are required in arid climates and more complex systems are required in wet climates. Although designs vary significantly from site to site, the basic layout of a multi-layered cap is summarized from top to bottom in Table 1 (EPA 1993). In this table each layer of a typical

cover system is listed along with its primary functions, construction materials, and general considerations given the waste material characteristics within the impoundment and site specific considerations.

The design of each cover system is site-specific and depends on the intended functions. The following functions were considered crucial for the Pond 2 cover system analyses and were used as a starting point for examining alternatives:

- Provide for high resistance to cover damage by impacts due to total long-term and differential waste settlement.
- Minimize surface water infiltration.
- Minimize long-term seepage generation.
- Prevent / limit seepage migration.
- Minimize surface erosion by controlling runoff.
- Provide for efficient site drainage and route surface water away from the impoundment.
- Minimize post-closure cover maintenance requirements and costs.
- Provide for sufficient final cover interface stability especially on embankment outcrops.

The following cover system functions are also considered during the design phase, but were not of immediate concern at Pond 2 based on the physical nature of the wastes contained:

- leachate management - currently being successfully managed by a lined Collection Ditch and Evaporation Ponds
- gas management - not a concern due to non-gas producing nature of waste materials

The most critical component of any cover system, in respect to selection of materials, is the Barrier Layer. It can consist of either a GCL, a low-permeability CCL, or a geomembrane (such as VLDPE or HDPE). GCL's are typically composed of a thin layer of processed bentonite sandwiched between two geosynthetic materials although other configurations are available. The bentonite expands to create the low-permeability barrier (typically between 1 and 5×10^{-9} cm/sec) that is self-healing. GCL's are either non-reinforced (adhesive bond between the bentonite and the synthetics) or reinforced (needle-punched) (Daniel 1995) (EPA 1995).

CCLs are only effective if they retain a certain moisture content and if differential settlement is very limited. CCLs are susceptible to cracking if the liner material dries out during or after construction, which is a concern in the arid St. George climate. In arid climates, GCLs are a better overall choice than CCLs for final covers because GCLs can better resist wet-dry cycles, freeze-thaw conditions, and differential settlement (Daniel 1995b). Thin membranes (geomembranes and GCLs) are more vulnerable to construction damage or post-construction puncture. Table 2 summarizes the relative advantages and disadvantages of the three types of Barrier Layer materials.

The next layer above the Barrier Layer, in an arid climate cover system design, is the Protection Layer. It protects underlying layers from dessication, freezing and thawing, and animal and root intrusion. It also helps maintain stability and provides for storage of infiltration water. In arid climates it may be important to cover the Protection Layer with a Surface Layer to protect the cover system from erosion due to both wind and surface water runoff as it can be difficult for vegetative growth to reestablish. If necessary, the Surface Layer typically consists of well graded gravel / rock / cobble mixtures designed to withstand erosive surface water and runoff forces. The Surface Layer also protects underlying layers from intrusion and promotes evapotranspiration.

3.2.2 Summary of Closure System Alternatives Analyzed

The cover system alternatives considered for the Apex Site consisted of six different designs, each of which could, if properly constructed, provide hydraulic isolation for wastes by:

- preventing or minimizing downward flow of precipitation inside and immediately next to the impoundment area
- performing effectively over the long-term without being damaged by characteristics of the underlying waste or erosion effects due to wind or surface water runoff

Table 3 (Final Closure Plan Alternatives) provides a summary of all layers in each cover system alternative analyzed and provides a range of estimated construction costs (no QA/QC or CM costs included). Each cover system design was based on analyses of many different variables and construction requirements. Each system has been successfully constructed at other waste facilities. The variables and requirements considered and used in the analyses are listed below in general order of importance:

- standard and acceptable designs for multi-layered cover systems as detailed by the EPA (EPA 1993, 1995 and 1998)
- physical setting of existing impoundment, embankment, and wastes
- methods for waste drainage and consolidation
- climate
- overall cover system effectiveness
- estimated construction cost
- constructability
- containment of waste / cover system tie-in to existing liner
- material availability (on-site, off-site, and synthetic)
- potential borrow soil permeability
- long-term erosion protection
- cover system slope / surface drainage

3.2.3 Alternative 2 (GCL) - Selected Alternative Cover System

Based on the overall objectives for the Pond 2 cover system and the variables and requirements as listed in the previous section, Hecla selected Alternative 2 (designated as the GCL alternative) as the optimal cover system for the impoundment. Alternative 2 consists of a three layer cover system which will, if properly constructed, provide hydraulic isolation for the wastes and perform effectively over the long-term. The three layers consist of from top to bottom:

- (1) Surface Layer
- (2) Protection Layer
- (3) Barrier Layer (GCL).

A Drainage Layer is not required due to arid climate and a Gas Collection Layer is not required as the wastes do not produce any gasses.

The basic design elements of the GCL Alternative are:

- > vertical wick drains
- > 1% final top slope
- > reconstructed and GCL lined impoundment embankments with 3.5:1 (H:V) outslopes
- > Surface Layer - 2 inch thick layer of $D_{50} = 1$ inch rock on the impoundment outslopes
- > Protection Layer - 12 inches of low permeability (2.6×10^{-6} cm/sec) on-site soils (designated as TP-1 material)
- > Barrier Layer - GCL with permeability of 1 to 5×10^{-9} cm/sec
- > widened diversion channel on the east side of the impoundment with erosion protection along the impoundment embankment

There were several compelling reasons why Alternative 2 (GCL) was preferable to other alternatives analyzed including:

- > no cost to purchase and ship on-site (TP-1) soils (utilized for the Protection Layer)
- > final permeability of TP-1 soils are not an issue (other alternatives utilized TP-1 soils for the Barrier Layer)
- > Barrier Layer constructed of GCL which is highly reliable, easy to obtain, very rapid to install, and less susceptible to damage if differential settlement of the wastes does occur
- > minimal QA/QC required during GCL installation compared to other alternatives

Potential drawbacks to Alternative 2 are:

- > could be the third most expensive cover system to construct (\$240,000 to \$400,000)
- > stability on the embankment sideslopes could be a concern due to low interface friction between GCL (if bentonite becomes hydrated) and underlying / overlying materials
- > potential insufficient quantity of TP-1 soils

Figure 5 shows the design profile for this alternative. Appendix C contains results from HELP model / seepage analyses for this alternative.

3.2.4 Modified Alternative Cover System (Blue Clay)

A Modified Alternative, selected by Hecla, is included in this Final Closure Plan to allow for some flexibility during bidding and construction phase of the project. The modification from the Selected Alternative consists of replacing the GCL Barrier Layer with a compacted clay liner (CCL). The CCL would be constructed with materials from nearby clay sources (Blue Clay from the St. George area). This Modified Alternative is Alternative 1 in Table 3 (designated as the Blue Clay alternative). The remaining design elements of this Modified Alternative are identical to Alternative 2 (GCL).

This alternative has potential positives and negatives similar to Alternative 2 except that it could potentially be the least expensive cover system to construct (\$190,000 to \$310,000). Potential drawbacks to this alternative include:

- > Blue Clay is only available in a piece-meal fashion as it is typically excavated from the foundation areas of smaller construction sites in and around St. George
- > make-up water would be required for processing and during placement of the Blue Clay Barrier Layer

Complete estimated construction costs for both the Selected Alternative (GCL) and the Modified Alternative (Blue Clay) are included in Section 5.0. Appendix C contains results from HELP model / seepage analyses for the Modified Alternative.

3.2.5 Additional Cover System Alternatives Analyzed

Four additional cover system alternatives were analyzed but not selected for the Final Closure Plan. Those alternatives, listed as Alternatives 3 through 6 in Table 3, were rejected from further consideration due to one or more of the following:

- > prohibitively high construction costs
- > significant potential for long-term and expensive maintenance / repairs
- > locally available and acceptable borrow materials
- > design that was more stringent than required - equally effective hydraulic isolation obtainable with significantly lower cost

Alternative 3 (On-Site Materials I) utilized on-site and off-site materials (TP-1 and Shivwit's Dam) for the Protection Layer and on-site materials (TP-1) for the Barrier Layer. It was rejected from further consideration due to the availability of less expensive and more reliable Barrier Layer materials. Both the GCL and Blue Clay (CCL) would be cheaper to install / process and place, would require significantly less processing water, and would provide for more effective long-term hydraulic isolation.

Alternative 4 (VLDPE / HDPE) included a geomembrane Barrier Layer in the design. It was included in the analyses as a potential alternative in case nearby, cost effective, and acceptable borrow soils for cover construction could not be located. As this was not the case, this alternative was rejected. This alternative also had the potential for more expensive construction and damage to the geomembrane during and / or after construction.

Alternative 5 (RCRA Type) was included in the analyses for cost comparison only. Its design was similar to a typical multi-layered RCRA cover utilized for hazardous wastes. It was eliminated from consideration as it was more stringent than required at this site, and it would be prohibitively expensive to construct (two to three times more expensive than the Selected Alternative and similarly effective cover system).

Alternative 6 (On-Site Materials II) would likely have been the least expensive to construct at an estimated cost of \$90,000 to \$150,000. However, as no drains were included in this alternative, it had the highest potential for expensive long-term maintenance and repairs due to differential settlements which would likely have occurred after completion of construction. Additionally, this alternative was eliminated from consideration due to

- requirement of additional fill placement (to 2%)
- greater damage potential due to the lack of an erosion protection layer

4.0 CONSTRUCTION SEQUENCE FOR SELECTED ALTERNATIVE

4.1 Overview

The objective of this Final Closure Plan is to drain and consolidate the existing wastes, prevent future seepage through the existing embankment, dispose of all existing Collection Ditch and Evaporation Pond materials, and hydraulically isolate for the long-term all wastes within Pond 2. The Final Closure Plan will consist of implementing Alternative 2 (GCL) as detailed in the following sections. In general, final closure construction activities will include the following three phases:

- Phase 1 Drainage and Consolidation
- Phase 2 Impoundment Regrading
- Phase 3 Final Cover System Construction

Individual construction steps required to complete each phase are discussed in greater detail in Sections 4.2, 4.3 and 4.4.

4.2 Phase 1 - Drainage and Consolidation

During Phase 1 free liquids within the waste materials will be sufficiently drained and evaporated, allowing the wastes to consolidate. Settlement of the top surface of the impoundment will be measured. Liquids emitting from the waste materials / wick drains will be managed to maximize evaporation rates and minimize construction time. Due to very high evaporation rates in this area, it is estimated that very little liquid will exist on the surface at any given time during this phase. When it has been determined that overall settlement has slowed to an acceptable rate, that is a rate at which additional settlement will not compromise the long-term integrity of the overall cover system, then construction of the final cover system can begin. Once seepage towards and through the existing embankment has decreased sufficiently, the Collection Ditch and Evaporation Pond materials will be removed and buried within the impoundment. Organizationally, Phase 1 is broken into the following six steps:

- Temporary Berm Construction
- Settlement Monument Installation
- Vertical Wick Drain Installation
- Drainage and Consolidation
- Liquid Evaporation
- Collection and Evaporation Pond(s) Removal and Disposal

Details for each step of Phase 1 are included in the sections below.

4.2.1 Temporary Berm Construction

Existing temporary cover materials will be utilized to construct a small containment berm along the outside perimeter of the impoundment and into berms which divide the top surface of the

impoundment into approximately 30 foot by 30 foot cells. The individual cells will enhance evaporation rates and allow for simpler management of liquids draining from the vertical wicks and liquids pumped from the existing Collection Ditch and Evaporation Ponds. The perimeter berm will be constructed approximately 20 to 30 feet back from the impoundment crest. Berms will be approximately one foot in height and constructed out of existing temporary cover materials. Compactive effort will be applied as necessary to minimize seepage between cells and potential berm failure.

4.2.2 Settlement Monument Installation

Settlement monuments will be installed at approximately six to eight locations into the top surface of the impoundment to monitor settlement which occurs after installation of the wick drains. Monuments will consist of vertical "stand pipes" attached to metal base plates. The base plates will be buried to a depth of approximately one to two feet into the temporary cover (for protection) and the stand pipes will extend approximately four to five feet above the ground surface. Initial baseline measurements will be collected prior to construction activities (drain installation). It is estimated that surveys will then be collected approximately every week for approximately four to six weeks, at which time it is estimated that the consolidation rate will have slowed to a point where final cover system construction can begin. Survey frequency will be adjusted as needed to accurately determine the consolidation rate.

4.2.3 Vertical Wick Drain Installation

Vertical wick drains will be installed through the temporary cover materials (if possible) and to within one to two feet of the existing bottom liner. These drains will provide a conduit for liquid flow to the surface of the impoundment. A typical wick drain consists of a prefabricated, flexible, polypropylene drain core surrounded by a strong, durable, non-woven polypropylene geotextile filter jacket. The jacket filter allows passage of fluids into the drain core while preventing piping of fines. It also helps to maintain the core shape and hydraulic capacity of the core channels. Figure 6 contains details on the materials, installation, and consolidation method with vertical wick drains.

Vertical wicks are typically installed utilizing a modified excavator that includes a structural mast. The hydraulics drive a mandrel, an anchor plate, and the attached end of the wick into the ground to the desired depth. The anchor plate prevents waste materials from entering and clogging the mandrel and it anchors the wick in place at the desired depth as the mandrel is being retracted. After the mandrel is withdrawn, the wick is cut off above the ground surface, the mast is moved to the next location, and the process is repeated. If drains can not be installed through the temporary cover materials due to large rocks and cobbles, then the driving unit will be moved laterally several feet and another attempt will be made. If it is still not possible to push through the temporary cover materials, a backhoe will

be utilized at that particular location to excavate a small opening through the temporary cover to a depth where the wick drain can be pushed. Estimated horizontal spacing between the drains will be between 3.4 and 5.4 feet. Appendix D contains the vertical wick drain analyses which is based on data collected from the October 2001 waste material drilling and sampling program (MEI 2002).

4.2.4 Drainage and Consolidation

After installation of the wick drains, fluid should begin to flow to the surface where it will evaporate, and if necessary be retained by the temporary berms. Additional loading will be added to the top surface, after installation of the perimeter vertical wick drains, to enhance and speed up drainage and consolidation, especially near the perimeter of the impoundment. This additional loading will consist of materials selectively excavated from the existing embankment resloping work discussed in Section 4.4.1 below. The availability and application this material will be dependent on the effectiveness of wick drains installed near the impoundment perimeter, the overall stability of the resloped embankment as construction proceeds, and the weather during this phase of construction (amount of precipitation and evaporation rate). This material will also provide the needed material for resloping the top surface to an overall 1% grade.

Overall settlement of each monument will be monitored and settlement rates will be calculated to verify when acceptable rates of consolidation have been reached. Due to the heterogeneity of the waste materials, it is likely that each area of the impoundment will produce different amounts of liquids, will experience varying amounts of settlement, and that acceptable settlement rates will be reached at different times. Acceptable settlement rates will be dependent on the location within the impoundment, and will in general be that rate at which it is determined that additional settlement will not compromise the long-term integrity of the overall cover system. Once an acceptable rate has been reached, and all retained fluids have been removed (evaporated or moved to another portion of the impoundment) then construction of the final cover system in that area of the impoundment can begin.

4.2.5 Liquid Evaporation

Fluids exiting the vertical wick drains, and fluids from the Evaporation Ponds and Collection Ditch will be retained on the top surface of the impoundment by the temporary berms discussed in Section 4.2.1 above. Fluids from the Evaporation Ponds and Collection Ditches will be pumped into the cells. Fluids within the cells will be managed depending on quantities produced, cell holding capacity, and overall weather conditions. As needed, fluids may be pumped from one cell to another to enhance evaporation rates and accelerate the overall construction process. In order to provide for a more stable outside embankment, decrease the potential for fluids in the temporary cover materials near the perimeter of the impoundment, and prepare for Phase 2 regrading work (Section 4.3), fluids will likely be pumped into cells nearer the center of the impoundment.



4.2.6 Collection Ditch and Evaporation Pond Removal and Disposal

Seepage flow into the Collection Ditch and Evaporation Ponds will continue to be monitored after construction has begun. Once leachate flow has stopped altogether for a period of at least one week, the Collection Ditch and Evaporation Pond materials will be removed and buried in the impoundment, or characterized and disposed of off-site at an authorized disposal facility. Monitoring of the former Collection Ditch / Evaporation Pond area will continue for an additional five years after final cover construction is completed. If leachate re-accumulates during this time period, an impervious liner material will be re-established to capture leachate, and these liquids will be placed on top of the impoundment for fluid evaporation. The liner material will be removed and properly disposed after the end of the five year period. Any other obviously contaminated materials encountered during this process will also be excavated and placed within the impoundment. All materials excavated during this step will, if possible, be buried beneath the current temporary cover.

4.3 Phase 2 - Impoundment Regrading

During Phase 2, most of the existing impoundment perimeter embankment will be removed and utilized as additional loading and temporary cover material for the impoundment's top surface. Depending on the amount of fluids produced through the wick drains and the evaporation rate (fluid management and weather), this phase will most likely be incremental, with certain areas of the impoundment accessible sooner than others. The objective of the regrading phase is to achieve approximate final impoundment configurations prior to construction of the final cover system (Phase 3).

4.3.1 Existing Embankment Resloping

A significant portion of the impoundment's existing perimeter embankment will be excavated and utilized as loading on the top surface to:

- increase vertical wick drainage
- increase waste material consolidation rates
- achieve the impoundment's overall top slope of approximately 1% (post drainage and consolidation)
- allow space for reconstruction of a more suitable perimeter embankment
- allow space for construction of a tie-in between the existing impoundment liner and the final cover system Barrier Layer (GCL)

The outslope of the current perimeter embankment varies from approximately 2:1 (H:V) to 3:1. The final re-constructed embankment will have an outslope of approximately 3½:1. During excavation the existing embankment will be cut back to approximately a 1:1 slope. Figure 7 shows a typical profile of the existing embankment, impoundment liner, the portion of that embankment which will be removed, and the temporary perimeter berm which will be constructed to retain potential surface fluids

during evaporation (Phase 1). Figure 8 shows a typical profile at the same location after selective removal of a portion of the embankment. As the excavated embankment will be steeper than the existing embankment, a slope stability analysis was conducted on the excavated embankment to determine an approximate factor of safety (F.O.S.). That analysis shows that the excavated embankment will be stable based on measured and correlated material strength values, and existing embankment configuration information collected to date. The critical F.O.S. for the excavated embankment is 1.6. Appendix E contains stability analyses for both the excavated embankment and the final embankment configuration (post-construction).

If during, or after, removal of portions of the existing embankment, unacceptable quantities of seepage occurs at the perimeter, potential solutions will include minor additional excavation, construction of a temporary clay or GCL covered berm, and / or pumping of excess fluids to the top of the impoundment. If a temporary clay or GCL covered berm is required, it would be tied into the existing impoundment liner to provide for any potential seepage containment. Once any unacceptable seepage stops and remaining liquids are removed, final cover surface grading can be completed and final cover system construction can begin (Section 4.4).

4.3.2 Final Cover Surface Grading

After fluids (if any) on top of the impoundment have evaporated sufficiently to allow for construction equipment to access the surface, settlement has slowed to an acceptable rate, and existing embankment materials have been excavated and placed on top of the impoundment, the top surface will be graded to create an approximate one percent (1%) slope down towards the perimeter of the impoundment, with a starting center elevation of 3,683 feet. Depending on condition and quantity of available existing embankment materials, overall quantities of settlement of the waste materials, and overall condition of the top surface of the impoundment, additional soils may be placed to achieve the final slope. These additional soils may be on-site or off-site materials depending on their availability and cost.

4.4 Phase 3 - Final Cover System Construction

The objective of Phase 3 will be to complete the final cover system. This will consist of placing the three final cover system layers, excavating / constructing and installing erosion protection for the surface water diversion channel, reconstructing the impoundment embankment.

4.4.1 Barrier Layer Placement

The Barrier Layer will be placed directly on top of the final regraded surface which will be smooth and free of all materials such as large stones, stakes, and other potentially damaging materials. The Barrier Layer material will consist of a GCL such as Bentofix, Bentomat, or Claymax. The GCL's

specified will be composed of a thin layer of processed bentonite sandwiched between two geosynthetic materials. When exposed to moisture the bentonite expands to create a low permeability barrier (typically 5×10^{-9} cm/sec) that is self-healing for holes up to 75 millimeters. A non-reinforced GCL such as Claymax 200R will be specified for the top surface of the impoundment where internal shear strength is not a concern due to the relative flatness of the slope. A reinforced needlepunched GCL with higher internal shear strength such as Bentomat ST or Bentofix Thermo Lock will be specified for the impoundment outslopes as they are significantly steeper than the top surface. Figures 9 and 10 show details on how the GCL will be tied into the existing impoundment liner and into the native soils outside of the impoundment.

4.4.2 Protection Layer Construction

The Protection Layer will be placed directly on the Barrier Layer and will consist of native materials (designated as TP-1) excavated from the southeast, east, and northeast sides of Hecla's property immediately adjacent to the impoundment. Based on the November of 2002 field investigation and laboratory test results, these soils consist mainly of sandy lean clays with a permeability of approximately 2.6×10^{-6} cm/sec. In order to provide sufficient material for this layer, a fairly significant borrow area will be excavated between the impoundment and Hecla's fence line. Utilization of this area as a borrow source will allow for a wider and more gently sloping diversion channel that is located further from the toe of the impoundment than the existing diversion channel. The larger diversion channel will provide for much improved long-term erosion protection for the impoundment embankment. Figures 11 and 12 show a plan view and two profiles of the borrow area / diversion channel.

Also included in this step is the reconstruction of the impoundment embankment. Several materials are suitable and available for use including those mentioned above (TP-1) and the Blue Clay which is locally available in the St. George area. Final material selection will depend on available quantities and purchase and placement costs. Figure 13 shows a profile of the reconstructed embankment including details on the liner tie-in and the final cover system configuration as it is constructed over the liner tie-in.

4.4.3 Surface Layer Placement

The Surface Layer will be placed on top of the Protection Layer. It will be the last layer of the cover system and will serve as erosion control on the impoundment outslopes. Storm water runoff and erosion protection analyses show that erosion protection larger than what will be the already in-place Protection Layer is not necessary on top of the impoundment. The same analyses show that the required erosion protection on the impoundment outslopes will consist of a two inch thick layer of well graded rock which has a D_{50} of one (1) inch. The design event for these analyses was 6-hour, 25-year

event. Storm depth of this event was 1.9 inches. Appendix F contains all runoff and erosion protection material sizing calculations.

4.4.4 Diversion Channel Erosion Protection Placement

Runoff and erosion protection sizing analyses were also conducted on the diversion channel immediately adjacent to the impoundment. These analyses show that long-term migration of the diversion channel towards the reclaimed impoundment embankment may occur, and therefore a six inch thick layer of well graded rock, which has a D_{50} of three (3) inches, should be entrenched from the toe of the impoundment to three feet below the diversion channel floor. This material will stabilize the impoundment outslope near the diversion channel from any potential long-term channel migration. This material will be extended one (1) foot above the channel floor also. The same 6-hour, 25-year storm event was utilized for these analyses. Appendix F contains calculations for runoff quantities and erosion protection material sizing for the diversion channel.

4.5 Modified Alternative Construction Sequencing

Hecla's Modified Alternative consists of substituting a CCL (Blue Clay) for the GCL Barrier Layer. Other than that one substitution, all other construction sequencing would remain the same as for the Selected Alternative. However, due to potential difficulties with obtaining sufficient quantities of Blue Clay in a timely manner, the overall construction process utilizing a CCL may be longer. In addition, water needs would most likely be greater, and more time would be required for processing, compacting, and quality assurance testing of the CCL.

5.0 COST ESTIMATE

The estimated total cost range for construction of the Selected Alternative (GCL) for the final cover system is \$343,920 to \$400,692. The estimated total cost range for construction of the Modified Alternative (Blue Clay) is \$290,920 to \$366,392. Major cost components for the Selected Alternative are included in Table 4. Appendix G contains a more complete cost estimate that provides details for major cost items, quantities, unit prices, and other factors that were included in the estimate. These estimates are based on the assumption that all work will be conducted by contractors and includes their overhead and profit. Unit prices for major earthwork activities and materials were based on cost estimates provided by local and national vendors, local material prices, and local equipment rates.

REFERENCES

- Daniel 1995a. Daniel, D.E., and Koerner, R.M., Waste Containment Facilities - Guidance for Construction Quality Assurance and Quality Control of Liner and Cover Systems, American Society of Civil Engineers, New York.
- Daniel 1995b. Daniel, D.E., Soil Barrier Layers Versus Geosynthetic Barriers in Landfill Cover Systems, *Proceedings from Landfill Closures, Environmental Protection and Land Recovery*, San Diego, CA, October 23-27, 1995, Geotechnical Special Publication No. 53, American Society of Civil Engineers, New York.
- EPA 1988. Guide to Technical Resources for the Design of Land Disposal Facilities, RREL, Center for Environmental Research Information, Cincinnati, OH, EPA/625/6-88/018.
- EPA 1989a. Final Covers on Hazardous Waste Landfills and Surface Impoundments, Office of Solid Waste and Emergency Response, Washington DC, EPA/530-SW-89-047, July 1989.
- EPA 1989b. Requirements for Hazardous Waste Landfill Design, Construction, and Closure, *Seminar Publication*, Center for Environmental Research Information, Cincinnati, OH, EPA/625/4-89/022.
- EPA 1991. Design and Construction of RCRA/CERCLA Final Covers, *Seminar Publication*, Office of Research and Development, Cincinnati, OH, EPA/625/4-91/025.
- EPA 1992. Final Cover Requirements for Municipal Solid Waste Landfills, *Environmental Fact Sheet*, Office of Solid Waste and Emergency Response, Washington DC, EPA/530-SW-91-084.
- EPA 1993. Landfill Covers Engineering Bulletin, EPA/540/S-93/500.
- EPA 1995. Report of 1995 Workshop on Geosynthetic Clay Liners, Office of Research and Development, NRMRL, Cincinnati, OH, EPA/600/R-96/149.
- EPA 1998. Evaluation of Subsurface Engineered Barriers at Waste Sites, *Technology Report*, EPA/542/R-98/005.

Hecla 2001. Results of October 2001 Investigations; Apex Site Pond 2 - Soils Sampling and Analysis, Memorandum to Randall Breedon, USEPA, from Hecla Mining Company, December 3, 2001.

MEI 2003a. Monster Engineering Inc. Apex Site - Pond 2, Conceptual Final Closure Alternatives, *Technical Memorandum* prepared for Chris Gypton, Hecla Mining Company, April 23, 2003.

MEI 2003b. Monster Engineering Inc. Potential Borrow Source Materials Investigation; Apex Site - Hecla Mining Company, *Technical Memorandum* prepared for Chris Gypton, Hecla Mining Company, February 3, 2003.

SMI 2001. Shepherd Miller Inc. Soil Sampling and Analysis Work Plan, prepared for Hecla Mining Company for the Apex Unit, August 30, 2001.

<p>Table 1</p> <p>Configuration of Typical Cover Systems</p>			
Layer	Primary Functions	Construction Materials	General Considerations for Apex Site / Pond 2
(1) Surface	<ul style="list-style-type: none"> ➤ promotes vegetative growth ➤ decreases erosion ➤ protects underlying layers from intrusion ➤ promotes evapotranspiration 	topsoil or gravel / cobbles	required to minimize wind / water erosion
(2) Protection	<ul style="list-style-type: none"> ➤ protects underlying layers from dessication, freeze-thaw, and intrusion ➤ maintains stability and storage of water 	mixed soils or gravel / cobbles	required for protection of Barrier Layer (freeze-thaw and dessication)
(3) Drainage	<ul style="list-style-type: none"> ➤ drains away infiltrating water to dissipate seepage forces 	sands, gravels, geotextiles, geonets, or geocomposites	not necessary due to arid climate (low precipitation / high evaporation rate)
(4) Barrier	<ul style="list-style-type: none"> ➤ minimizes infiltration of surface water ➤ reduces gas emissions 	compacted, GCL (geosynthetic clay liner), geomembranes, or composites	although likely needed, does not have to be as low a permeability as 1×10^{-7} cm/sec (for RCRA hazardous waste)
(5) Gas Collection	<ul style="list-style-type: none"> ➤ transmits gas to collection points for removal 	sand, geotextiles, or geonet	not necessary due to non-gas producing nature of waste

Table 2
Advantages and Disadvantages of Barrier Layer Materials

Barrier Layer Material	Advantages	Disadvantages
GCL	<ul style="list-style-type: none"> ➤ rapid installation ➤ very low hydraulic conductivity if properly installed ➤ low cost ➤ excellent resistance to freeze-thaw ➤ can withstand large differential settlement ➤ excellent self-healing characteristics ➤ not dependent on locally available soils ➤ low weight and volume consumed by liner ➤ easy to repair 	<ul style="list-style-type: none"> ➤ low shear strength of hydrated bentonite ➤ can be punctured during or after construction ➤ dry bentonite is not impermeable to gas ➤ potential strength concerns at interfaces with other materials
CCL	<ul style="list-style-type: none"> ➤ long history of use ➤ regulatory approval is virtually assured ➤ large thickness ensures that layer will not be breached ➤ large thickness provides physical separation between waste and surface environment ➤ cost can be low if material is locally available 	<ul style="list-style-type: none"> ➤ soil can desiccate and crack ➤ liner must be protected from freezing ➤ low resistance to cracking from differential settlement ➤ difficult to compact soils above compressible waste ➤ suitable soils not always locally available ➤ difficult to repair if damaged ➤ slow construction
Geomembrane	<ul style="list-style-type: none"> ➤ rapid installation ➤ virtually impermeable to water if properly installed ➤ low cost ➤ not vulnerable to desiccation or freeze-thaw damage ➤ can withstand large tensile strains ➤ low weight and volume consumed by liner ➤ easy to repair 	<ul style="list-style-type: none"> ➤ potential strength concerns at interfaces with other materials ➤ can be punctured during or after construction

Table 3
Final Closure Plan Alternatives

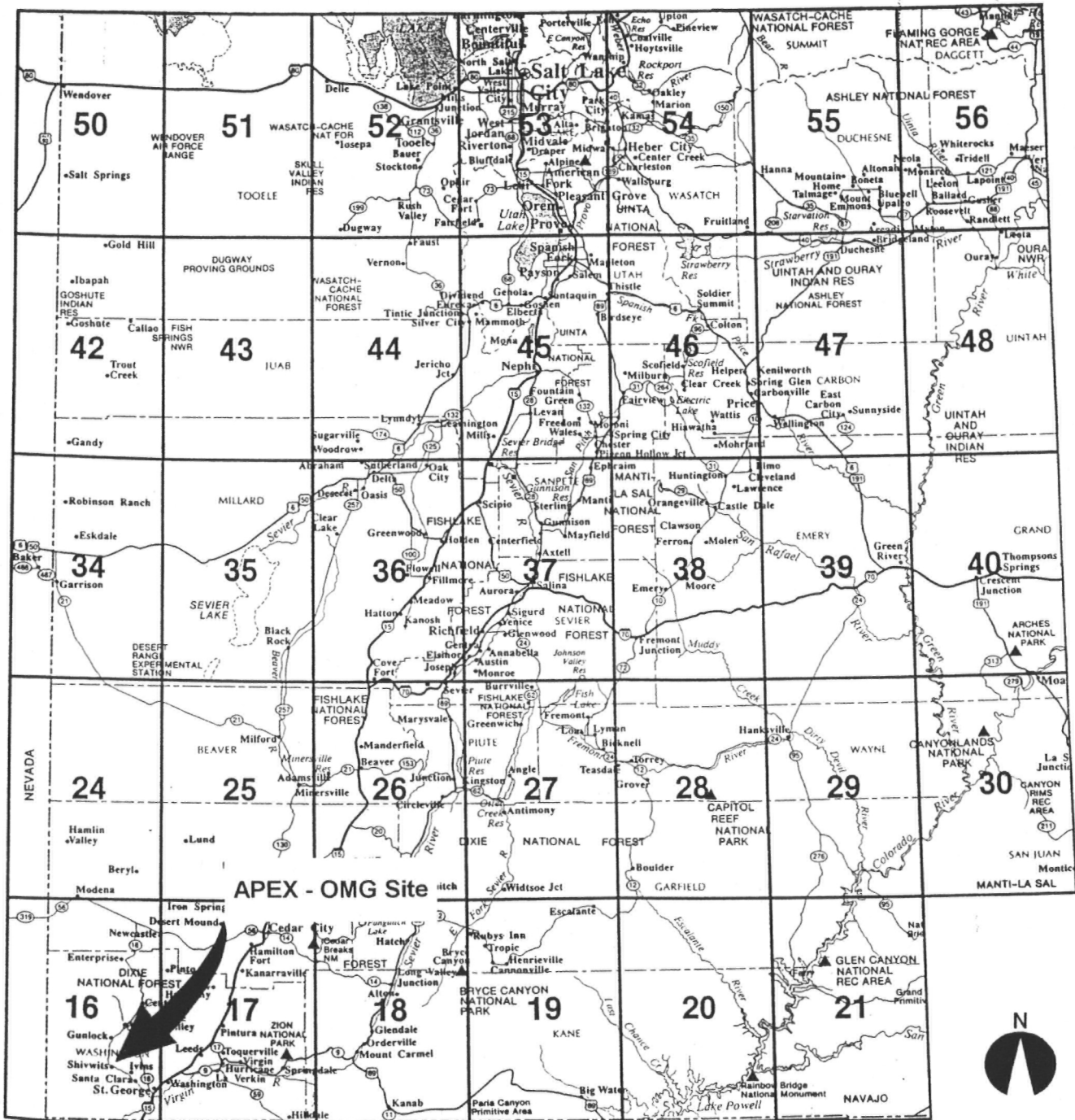
Variables	Alternatives					
	Modified Alternative	Selected Alternative	Rejected Alternatives			
	1 Blue Clay	2 GCL	3 On-Site Materials I	4 VLDPE / HDPE	5 RCRA Type	6 On-Site Materials II
Drainage	Vertical Wicks	Vertical Wicks	Vertical Wicks	Vertical Wicks	Vertical Wicks	No Drains
Top Slope	1%	1%	1%	1%	1%	2%
Cover Layer Descriptions	Surface Layer 2" of $D_{50} = 1"$ Rock (outslopes only)	Surface Layer 2" of $D_{50} = 1"$ Rock (outslopes only)	Surface Layer 2" of $D_{50} = 1"$ Rock (outslopes only)	Surface Layer 2" of $D_{50} = 1"$ Rock (outslopes only)	Surface Layer 2" of $D_{50} = 1"$ Rock (outslopes only)	
	Protection Layer 12" on-site materials TP-1 (2.6×10^{-6} cm/sec)	Protection Layer 12" on-site materials TP-1 (2.6×10^{-6} cm/sec)	Protection Layer 12" on-site & off-site materials Shivwits Dam (6.3×10^{-6} cm/sec)	Protection Layer 6" on-site materials TP-1 (2.6×10^{-6} cm/sec)	Protection Layer 18" on-site & off-site materials	Protection Layer 12" on-site & off-site materials Shivwits Dam (6.3×10^{-6} cm/sec)
					Biotic Barrier Layer 6" Cobble	
					Geosynthetic Filter	
					12" Drainage Layer	
					20-mil Geomembrane	
	Barrier Layer 12" thick Blue Clay (approx. 1×10^{-7} to 1×10^{-8} cm/sec)	Barrier Layer GCL (1 to 5×10^{-9} cm/sec)	Barrier Layer 12" on-site materials TP-1 (2.6×10^{-6} cm/sec)	Barrier Layer HDPE or VLDPE textured	Barrier Layer 24" Blue Clay (10^{-7} to 10^{-8} cm/sec) or GCL (1 to 5×10^{-9} cm/sec)	Barrier Layer 12" on-site materials TP-1 (2.6×10^{-6} cm/sec)
				6" Sand Layer		
	Cut & Fill Existing to 1% Slope	Cut & Fill Existing to 1% Slope	Cut & Fill Existing to 1% Slope	Cut & Fill Existing to 1% Slope	Cut & Fill Existing to 1% Slope	Cut & Fill Existing to 2% Slope
	Waste	Waste	Waste	Waste	Waste	Waste
Notes	1, 2, 3, 4	1, 2, 5	1, 2, 6	1, 2, 7	1, 2, 8, 9	6, 10, 11, 12
Est. Cost ¹³	\$190k to \$310k	\$240k to \$400k	\$210k to \$340k	\$300k to \$480k	\$570k to \$930k	\$90k to \$150k

Notes for Table 3 - Final Closure Plan Alternatives:

1. Vertical wick drains will substantially decrease consolidation time, decrease the amount of additional consolidation after placement of final cover, and speed up the process of removing the Collection Ditch and Evaporation Ponds.
2. Rock (Surface Layer) is in lieu of growth media / revegetation. Rock will provide for superior long-term erosion protection and there will be no requirements for establishment of vegetation.
3. Blue Clay is the best available low-permeability material source in the St. George area. Laboratory tests show permeability is typically less than 1×10^{-7} cm/sec.
4. Blue Clay would potentially take significantly longer to purchase and deliver as it would have to be delivered in a piece-meal fashion.
5. GCL costs are preliminary and dependent on manufacturer, materials, and contractor (installer) selected.
6. Permeability of Barrier Layer estimated at 2.6×10^{-6} cm/sec.
7. 6" sand layer above waste is utilized to protect the HDPE / VLDPE liner.
8. RCRA Type - Typical multilayered cap for RCRA hazardous waste application.
9. Barrier Layer constructed with either 24" Blue Clay or GCL.
10. No drains installed with this alternative so there would be additional problems and costs associated with:
 - > longer time to allow for drainage and consolidation
 - > potentially more settlement after completion of the cover
 - > disposal of Collection Ditch / Evaporation Ponds and liners
 - > either installation of new "lined" berm or tie in into old liner
11. Additional costs would need to be added to this alternative due to longer time period required for pumping of fluids on to the top of the impoundment.
12. Pond materials likely to experience additional consolidation after final cover placement with this alternative. Slope design of 2% on the top surface would allow for greater consolidation while maintaining positive drainage off the impoundment.
13. Estimated Costs - Initial estimates for comparison of alternatives only. Costs include purchase, delivery, and placement of cover materials only. No CM, QA/QC, or design costs included.

Table 4
Cost Estimate - Selected Alternative (GCL)

Item #	Item	Quantity	Units	Purchase/ Excavation (\$/Unit)	Deliver (\$/Unit)	Place (\$/Unit)	Total (\$/Unit)	Estimated Cost Range	
								Low	High
1	Mobilization - Earthmoving Contractor	1	LS	\$2,000	NA	NA	\$2,000	\$2,000	\$2,400
	Phase I - Drainage & Consolidation								
2	Construct Exterior Containment Berm	1	LS	NA	\$0	\$300	\$300	\$300	\$450
3	Fabricate and Install Settlement Monuments	6	EA	\$50	\$0	\$200	\$250	\$1,500	\$1,800
4	Install Vertical Wick Drains @ 4 O.C.	200,000	LF	\$0.43	\$0.075	\$0.00	\$0.51	\$101,000	\$111,100
5	Construct Interior Containment Berms @ 30' O.C.	1	LS	NA	\$0	\$1,280	\$1,280	\$1,280	\$1,664
6	Remove & Dispose Evaporated Salts (top surface)	1	LS	NA	\$0	\$1,200	\$1,200	\$1,200	\$2,400
7	Remove & Dispose Evap Pond/Coll. Ditch Materials	1	LS	NA	\$0	\$1,500	\$1,500	\$1,500	\$2,250
	Phase II - Regrading								
8	Excavate Existing Embankment	9,300	CY	NA	\$0	\$0.56	\$0.56	\$5,250	\$7,875
9	Place Preloading on Top Surface	9,300	CY	NA	\$0	\$0.32	\$0.32	\$3,000	\$3,600
10	Final Grading of 1% Surface	9,300	CY	NA	\$0	\$0.24	\$0.24	\$2,250	\$3,150
	Phase III - Final Cover System Construction								
11	Mobilization - GCL Contractor / Installer	1	LS	\$2,500	\$0.00	\$0.00	\$2,500	\$2,500	\$3,000
12	Place Barrier Layer (GCL) - top	195,750	SF	\$0.25	\$0.05	\$0.10	\$0.40	\$78,000	\$85,800
13	Place Barrier Layer (GCL) - outslopes	49,500	SF	\$0.31	\$0.05	\$0.10	\$0.46	\$23,000	\$25,300
14	Strip & Grub Vegetation	1	LS	\$0.00	\$0.00	\$2,250	\$2,250	\$2,250	\$2,700
15	Excavate Diversion Channel	11,500	CY	\$0.65	\$0.26	\$0.00	\$0.91	\$10,500	\$12,600
16	Place Protection Layer (12" on-site materials)	8,000	CY	\$0.00	\$0.25	\$0.56	\$0.81	\$6,500	\$10,400
17	Reconstruct Outside Embankment	3,500	CY	\$0.00	\$0.29	\$1.81	\$2.10	\$7,350	\$11,025
18	Finish Grade 1% Surface - top	1	LS	\$0.00	\$0.00	\$2,250	\$2,250	\$2,250	\$4,500
19	Place Surface Layer (outslopes only) D50 = 1"	300	CY	\$7.00	\$4.00	\$5.00	\$16.00	\$4,800	\$5,760
20	Place Diversion Channel Erosion Protection (3" rock)	200	CY	\$7.00	\$4.20	\$7.75	\$18.95	\$3,790	\$4,548
21	Dust / Erosion Control	1	LS	\$2,700	NA	NA	\$2,700	\$2,700	\$2,970
22	QA / QC	60	Days	\$650	NA	NA	\$650	\$39,000	\$46,800
23	Construction Management	60	Days	\$500	NA	NA	\$500	\$30,000	\$33,000
24	Surveying (Settl. Mon., All Surfaces)	15	Days	\$800	NA	NA	\$800	\$12,000	\$18,000
							Totals	\$343,920	\$400,692



Scale 1" = 40 miles

PROJECT Apex
 LOCATION St. George, Utah
 DATE 3/25/04

Figure 1
Site Location Map

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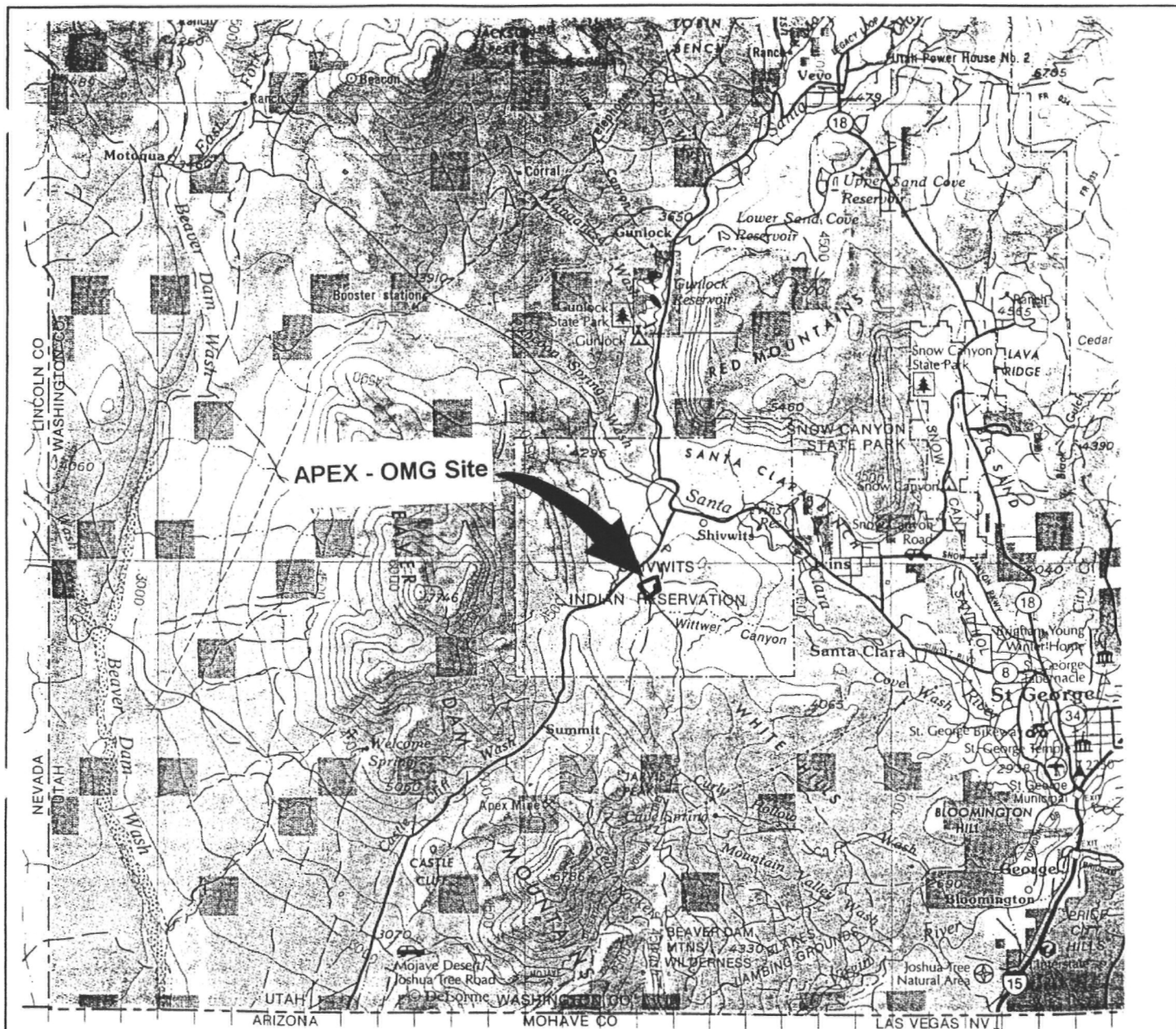


Monster Engineering Inc.



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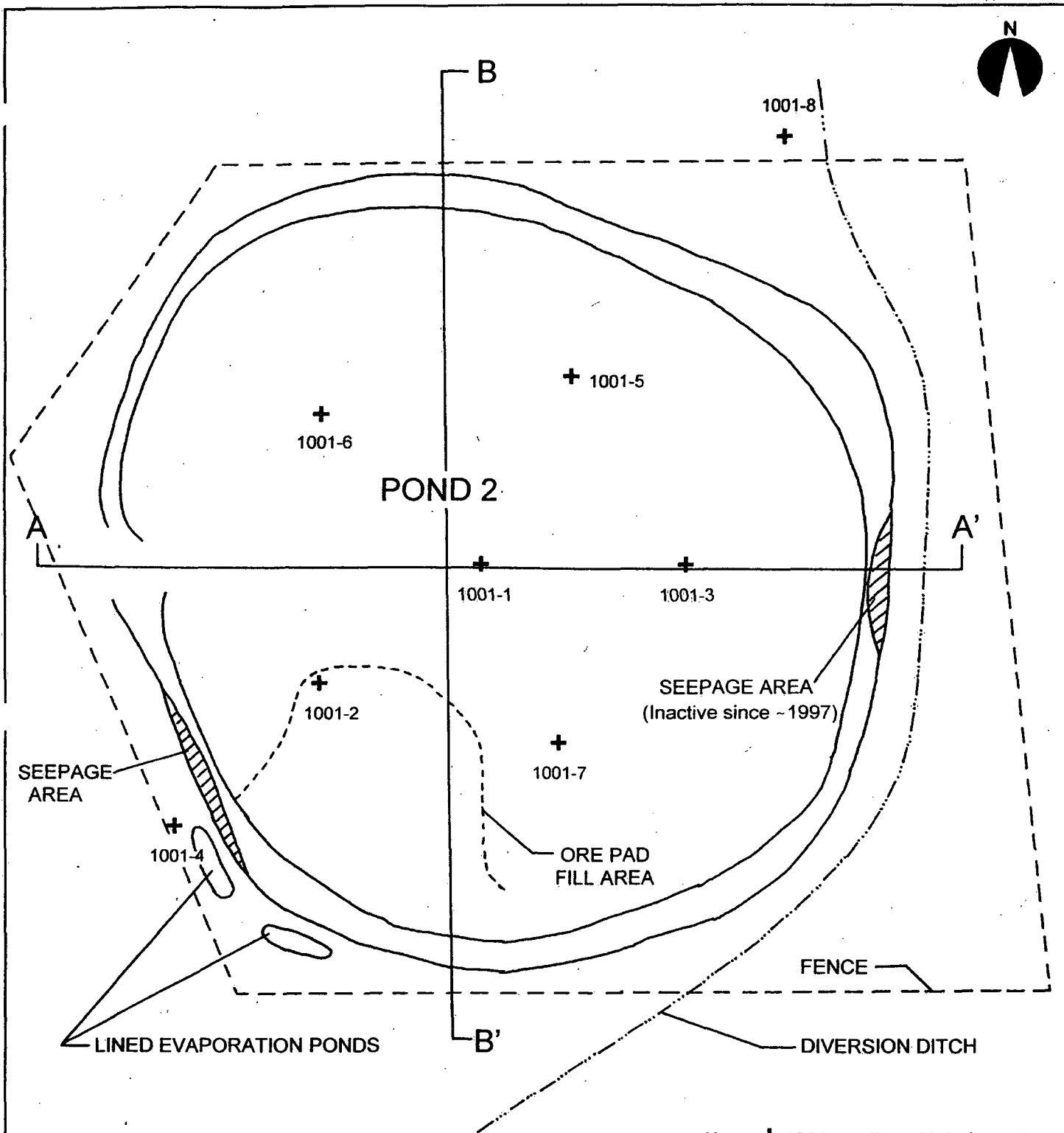


A00030



Scale 1" = 4 miles

<p>PROJECT <u>Apex</u></p> <p>LOCATION <u>St. George, Utah</u></p> <p>DATE <u>3/25/04</u></p>	<p>Figure 2</p> <p>Project Location Map</p>	
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Scale 1" = 100'

Note: + 1001-8 = Bore Hole Locations

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Figure 3
 Pond 2 - Plan View

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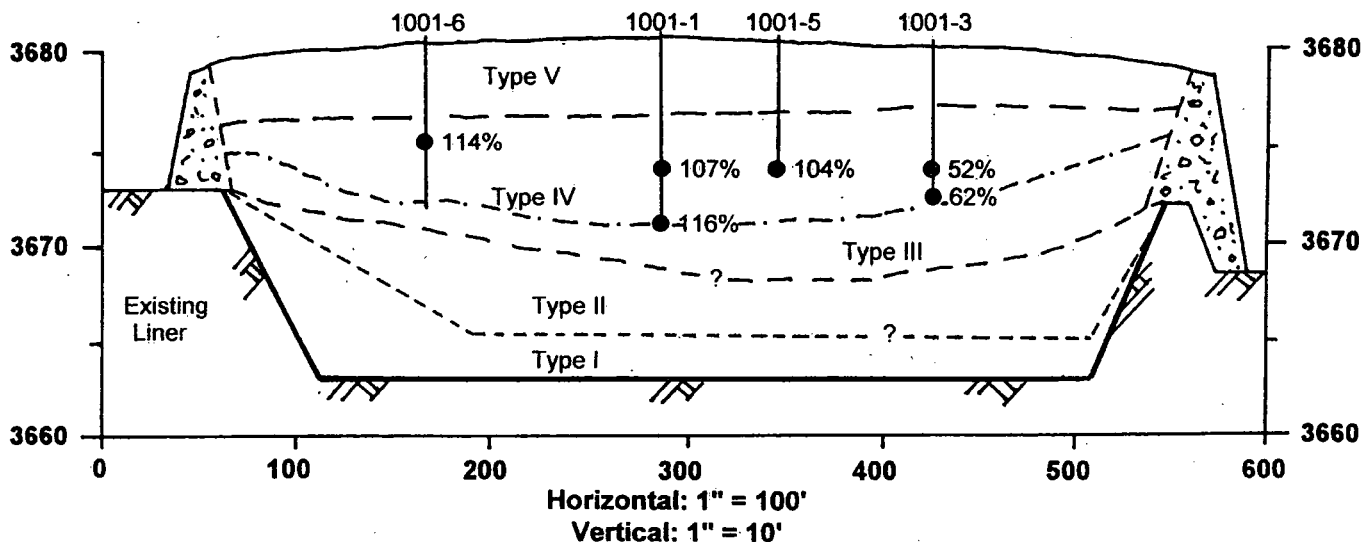
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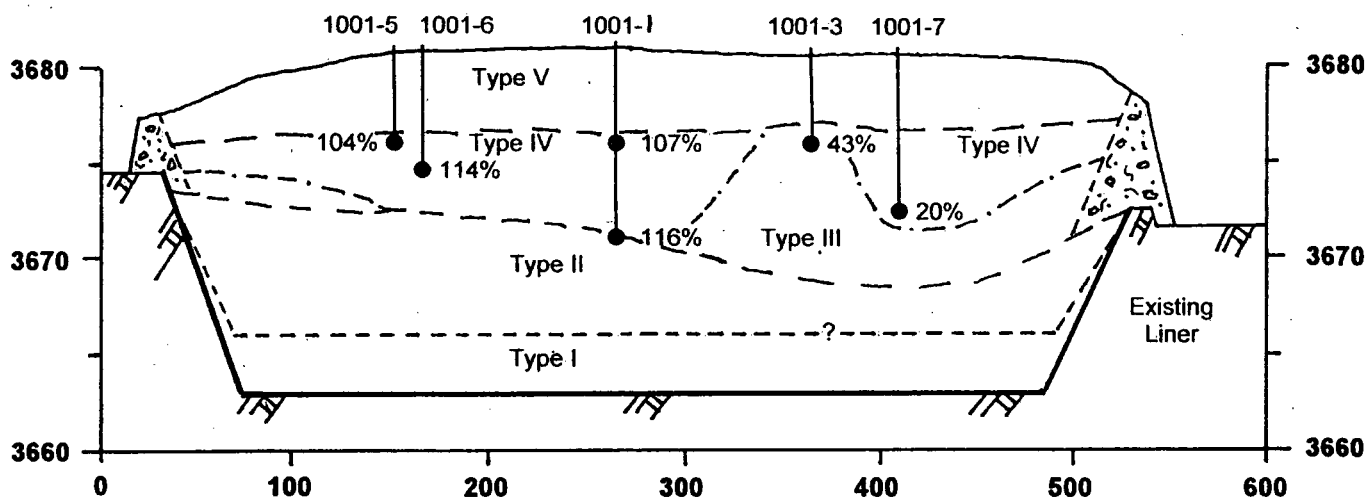


100032

Section A - A'



Section B - B'



Material Types:

- I - SGMC Tailings
- II - SGMC 2A, 1B, 1C, 3BN, 3BS, 3A
- III - Hecla Pond 1A/B - Soil Mixture
- IV - Hecla Pond 3A (plus old liner materials, pumped as slurry)
- V - Temporary Cover Material

Notes:

- 114% (sample moisture content)
- Pond Contents are estimates only.
- Borehole locations are estimates.

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 DATE 3/25/04

Figure 4
 Pond 2 - Profiles

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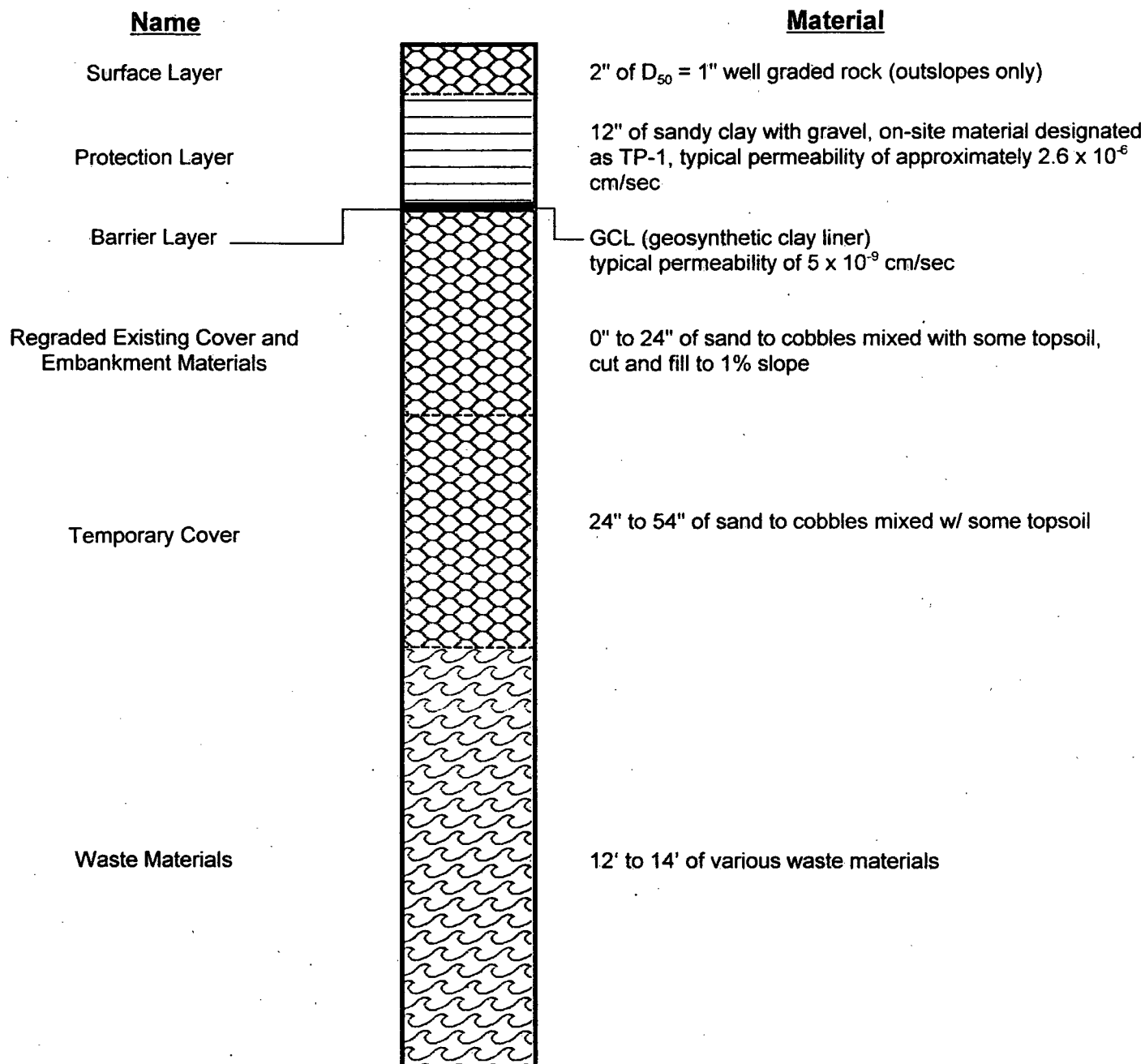


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Selected Cover System Alternative Profile



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 DATE 3/25/04

Figure 5
Selected Cover System Alternative Profile

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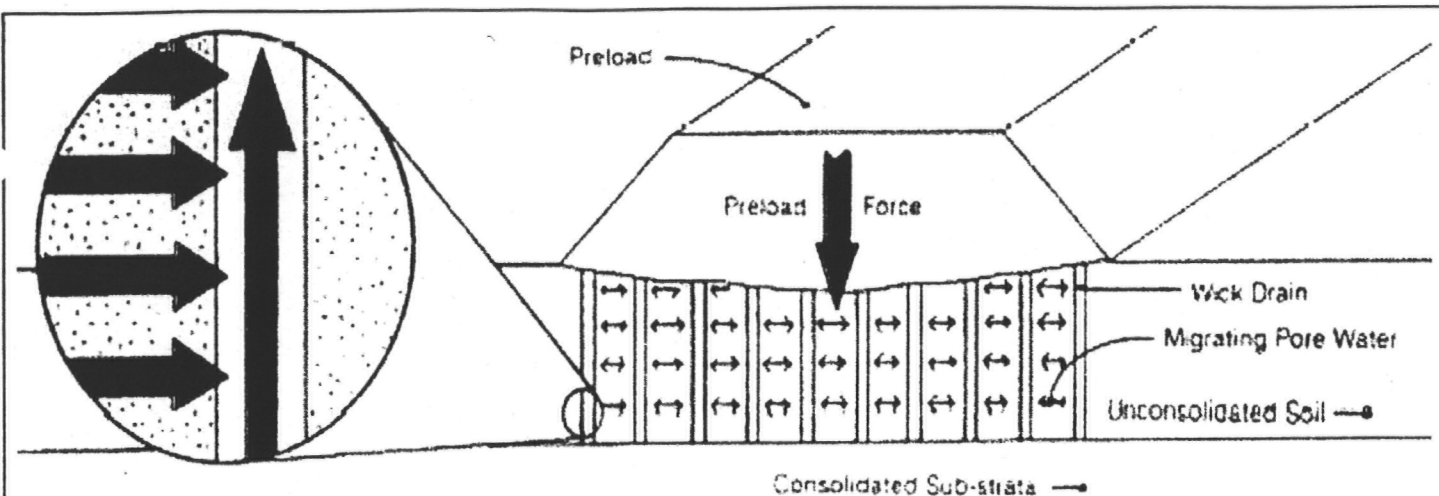


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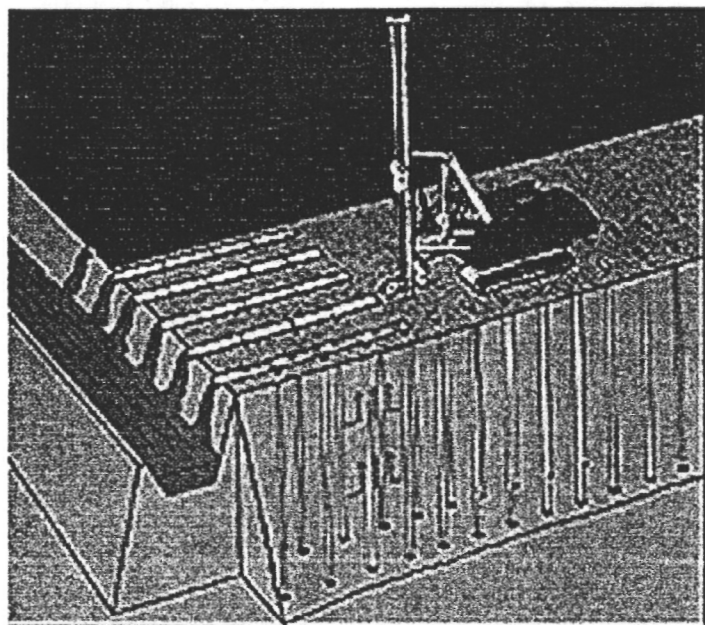
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A00034

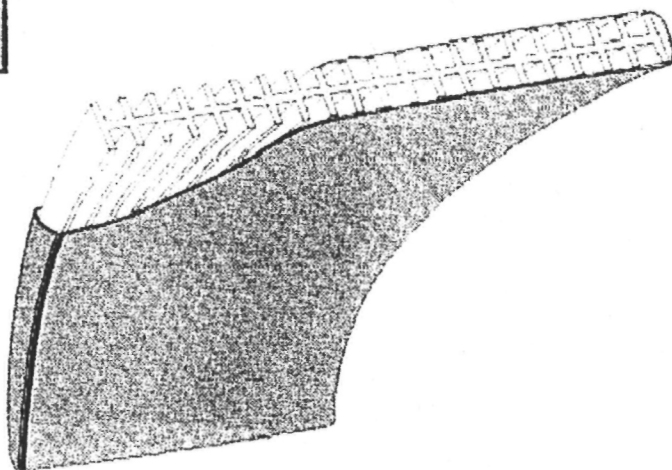


Consolidating Using Wick Drains



Typical Installation - 3.4' to 5.4' horizontal spacing

Cutaway Section of Mebra Wick Drain
(from NILEX)



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DATE 3/25/04

Figure 6
Typical Vertical Wick Drain Installation

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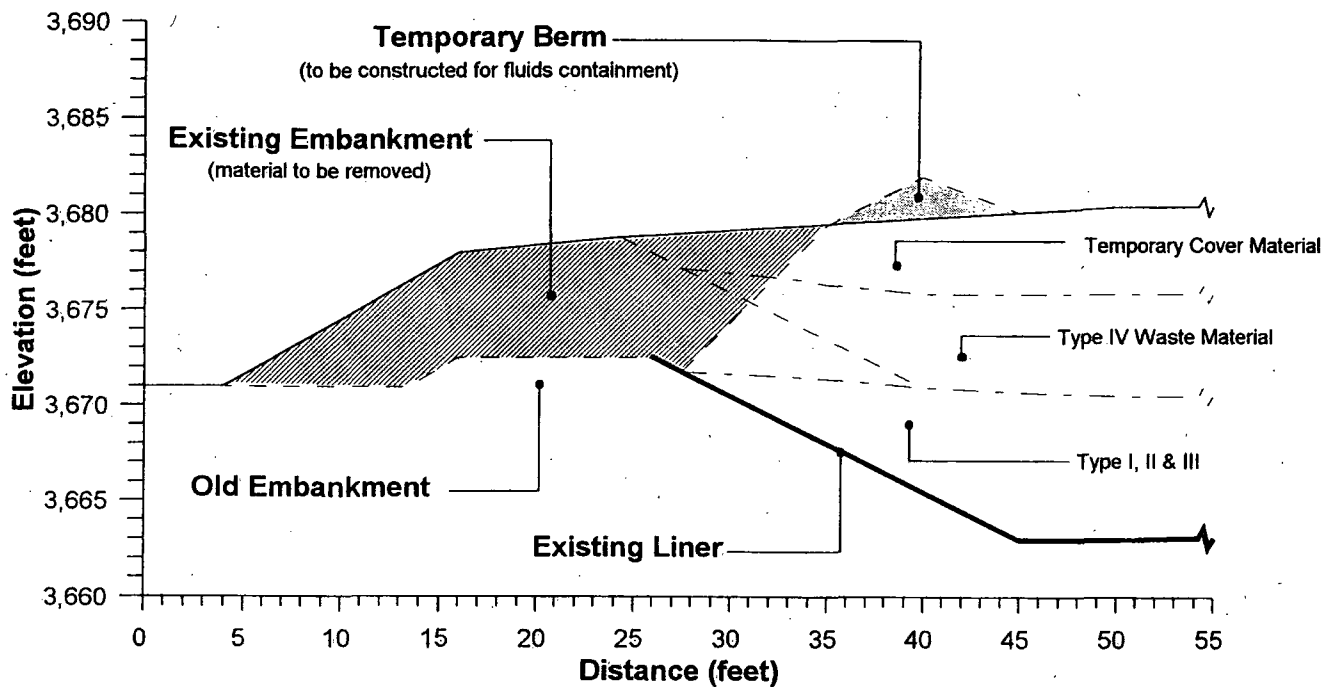
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A00035

Typical Embankment Profile

(pre-embankment removal)



PROJECT Apex
 LOCATION St. George, Utah
 DATE 3/25/04

Figure 7

Typical Embankment Profile
 (pre-embankment removal)

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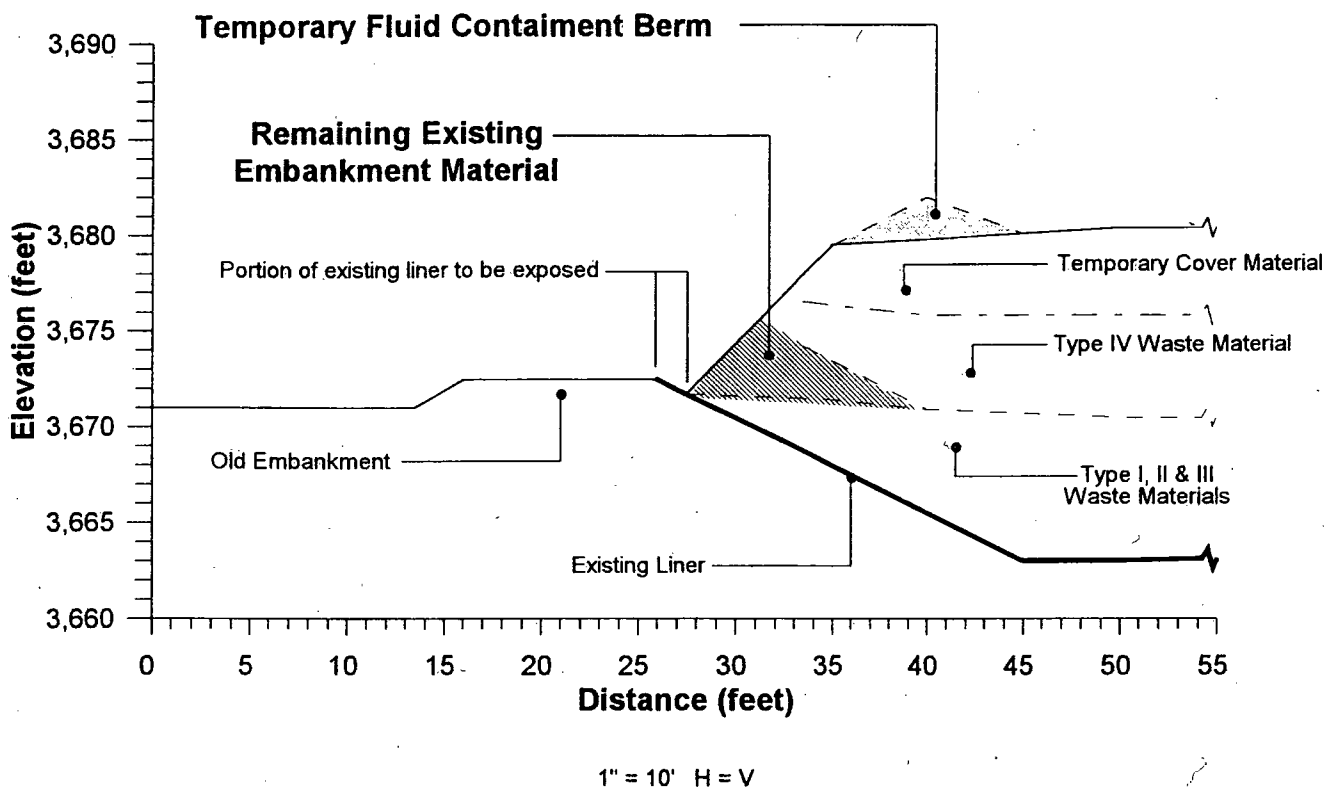
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A00036

Typical Embankment Profile

(post-embankment removal)



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 LOCATION St. George, Utah
 DATE 3/25/04

Figure 8
Typical Embankment Profile
 (post-embankment removal)

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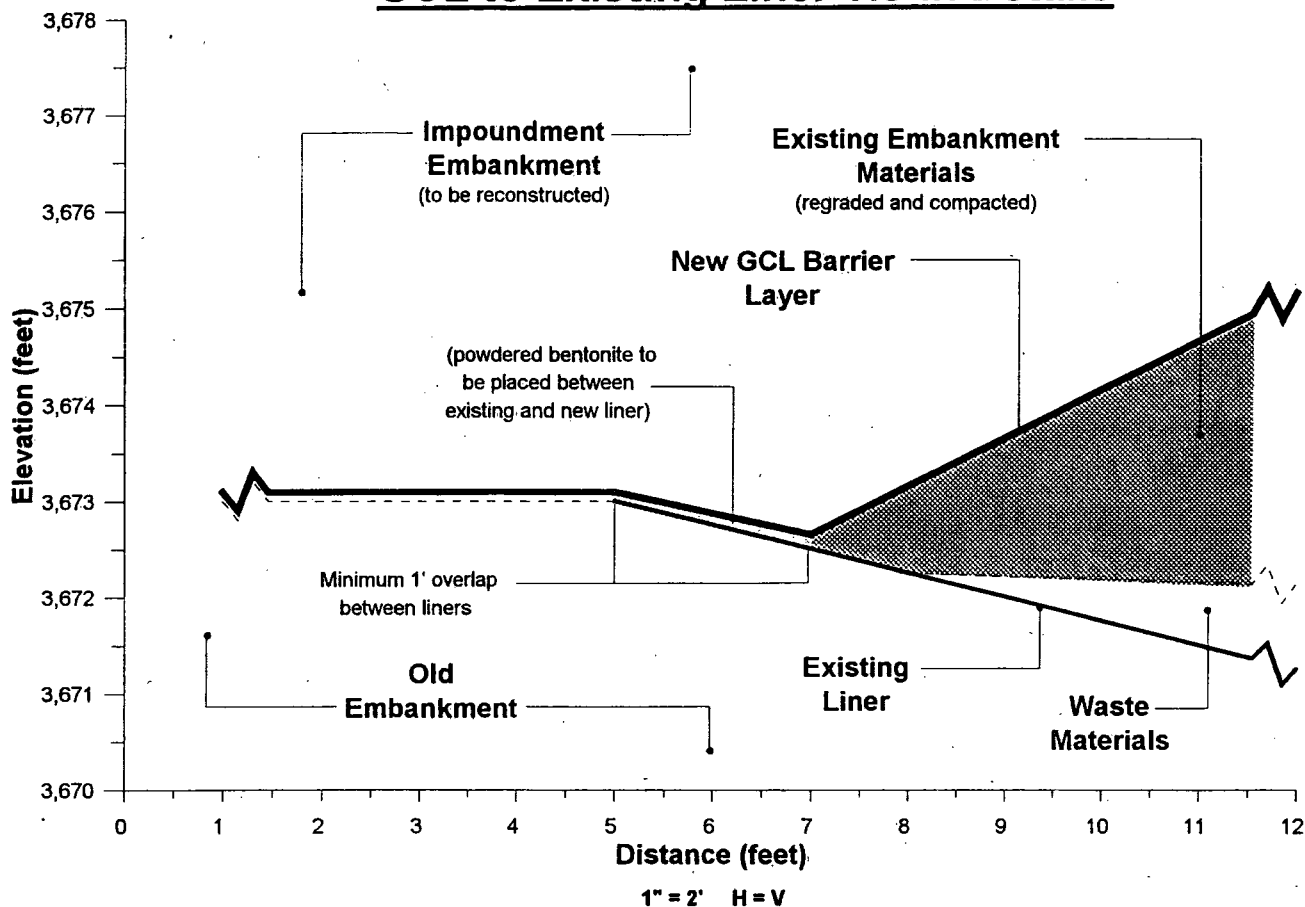
Monster Engineering Inc.

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A00037

GCL to Existing Liner Tie-in Details



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 LOCATION St. George, Utah
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Figure 9
GCL to Existing Liner Tie-in Details

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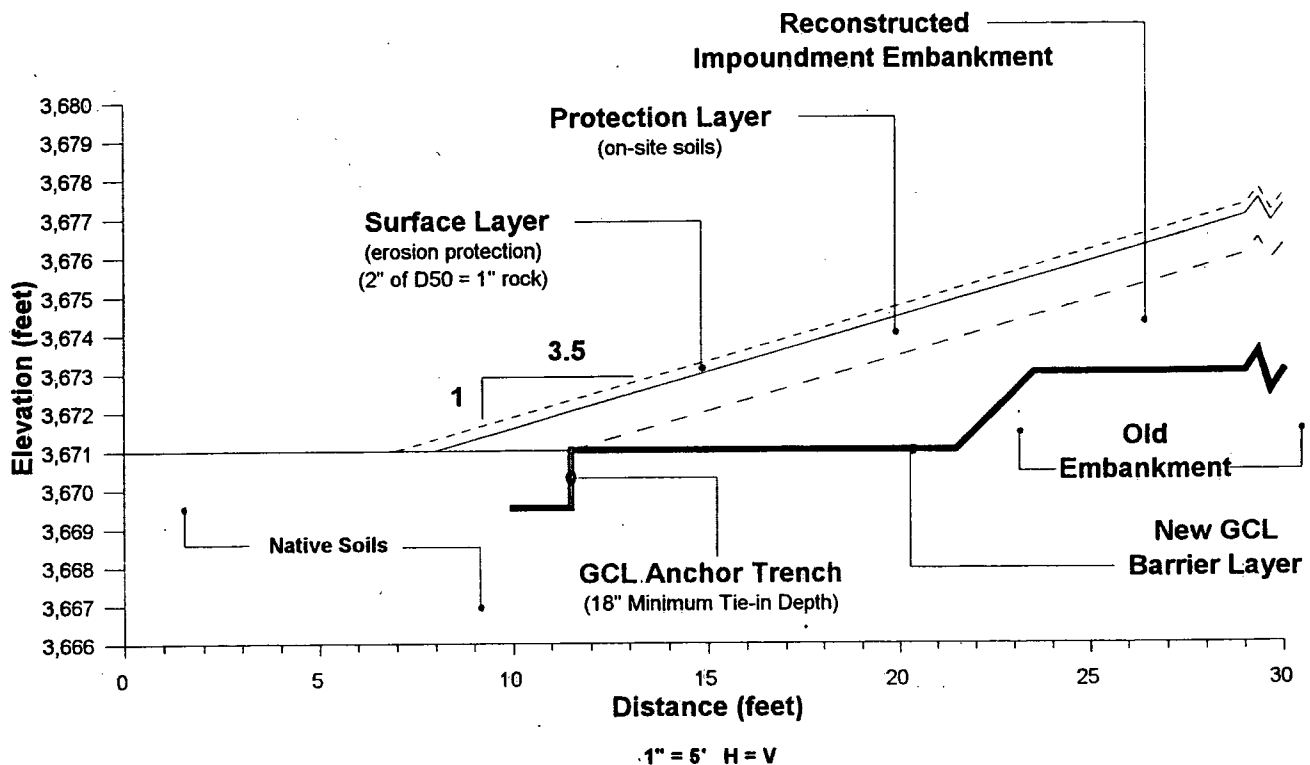
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Prepared for:



A00038

GCL to Native Soils Tie-in Details



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Figure 10
GCL to Native Soils Tie-in Details

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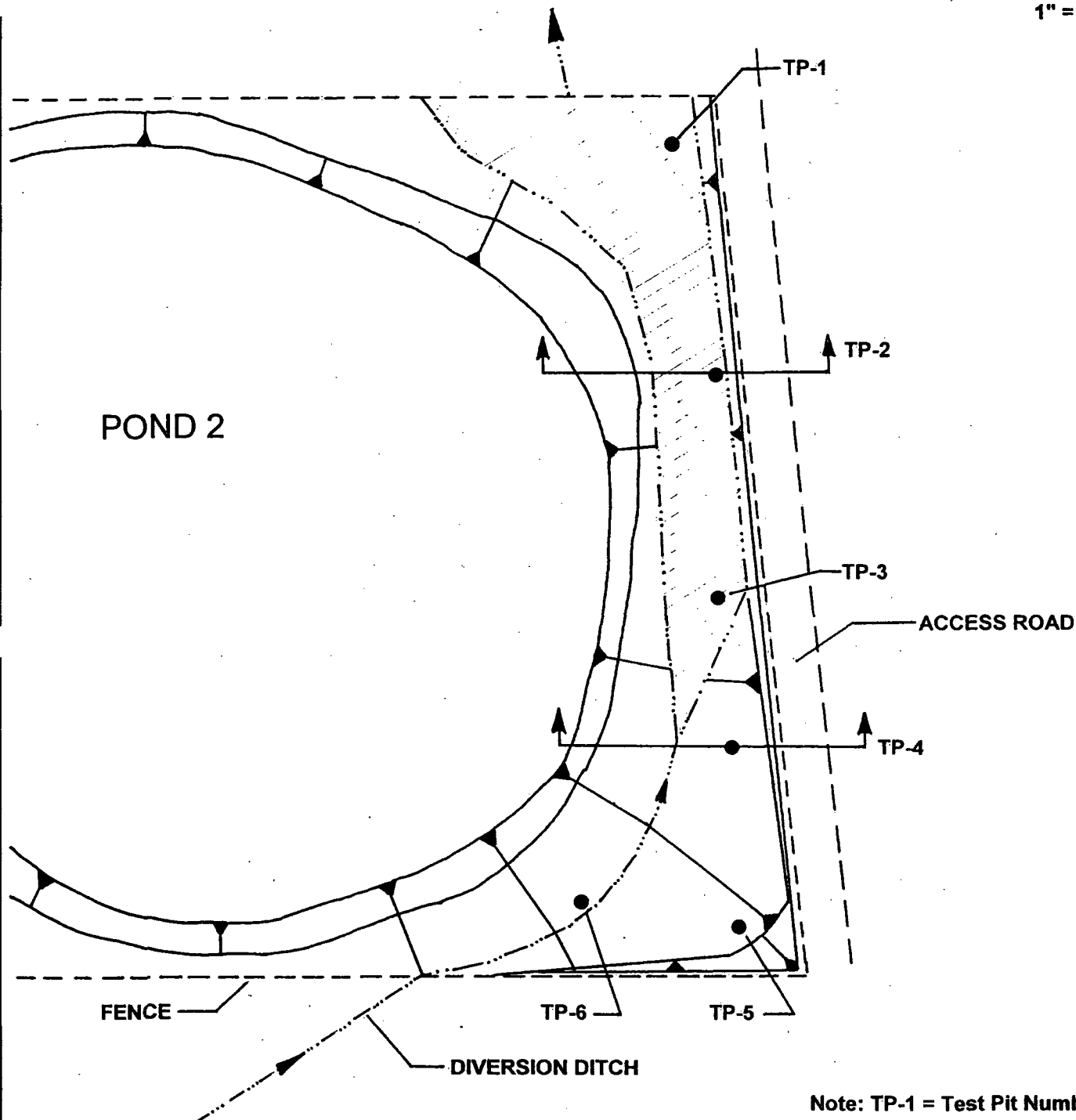
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A00039



1" = 100'



Note: TP-1 = Test Pit Number 1

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Figure 11
Borrow Area / Diversion Channel Plan View

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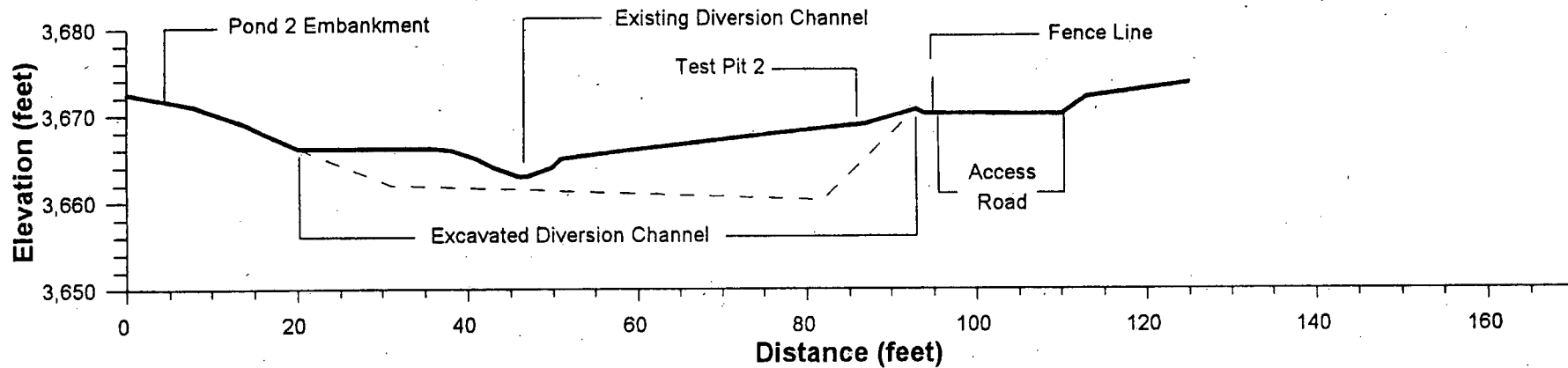
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100040

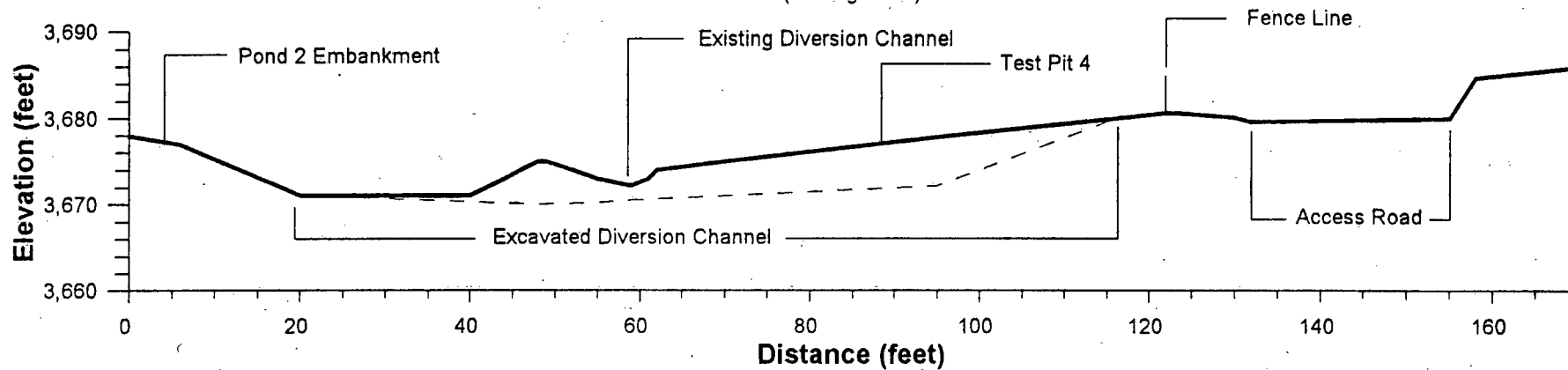
Channel Cross Section at TP- 2

(looking north)



Channel Cross Section at TP- 4

(looking north)



PROJECT Apex
 LOCATION St. George, Utah
 DATE 3/25/04

Figure 12.
 Borrow Area / Diversion Channel Excavation Profiles

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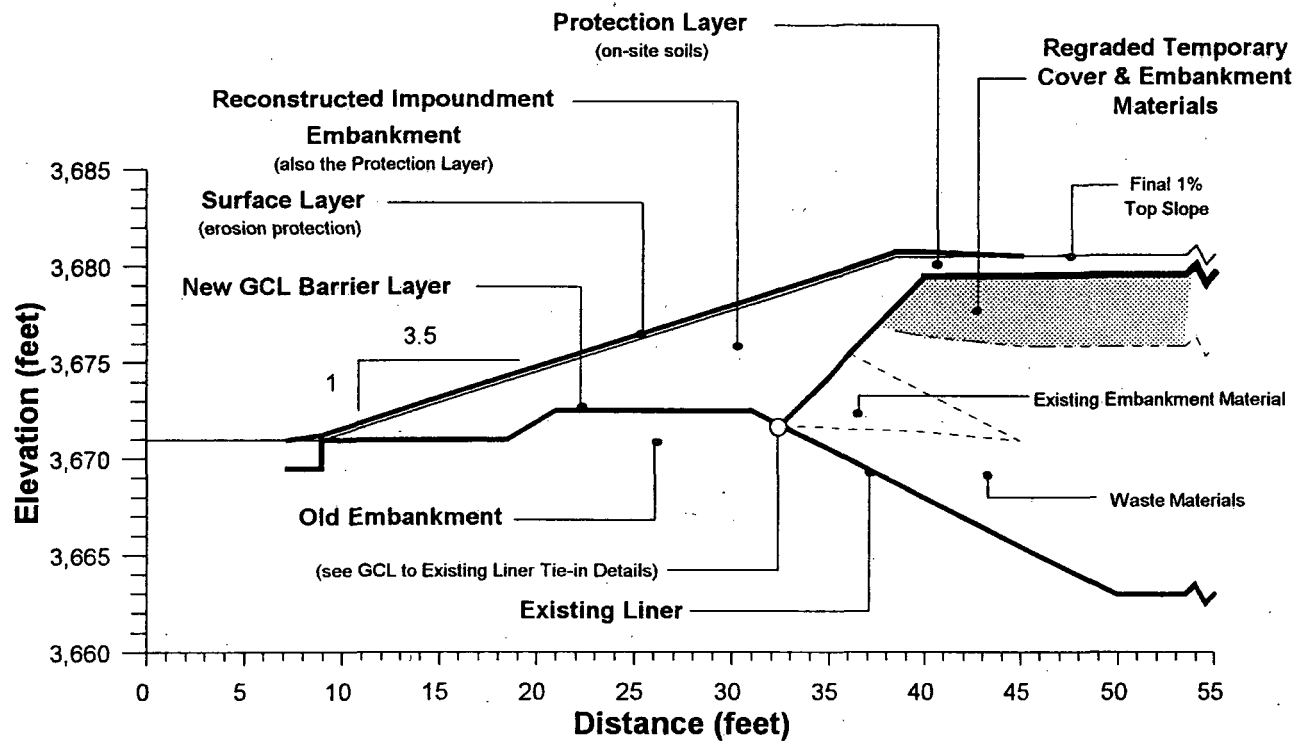
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Reconstructed Embankment Profile



PROJECT Apex
 LOCATION St. George, Utah
 DATE 3/25/04

Figure 13
Reconstructed Embankment Profile

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Prepared by:



Monster Engineering Inc.

Prepared for:



Apex Site

Final Engineering Report

for

Pond 2 Closure

Appendices

Appendix

Name

A	Waste Material Sampling and Analysis - Laboratory Testing Results Summary
B	Potential Borrow Source Materials Investigation
C	HELP Modeling Results
D	Vertical Wick Drain Analysis
E	Stability Analyses
F	Runoff Evaluation and Erosion Protection Sizing Analyses
G	Cost Estimate
H	Monitoring and Maintenance Plan
I	Construction Quality Control (CQC) Plan

Appendix A

Waste Material Sampling and Analysis - Laboratory Testing Results Summary

Appendix A
Waste Material Sampling and Analysis - Laboratory Testing Results Summary

In October of 2001 Hecla conducted a drilling, sampling, and laboratory testing program to determine the extent of, and potential for, seepage migration from Pond 2 (the impoundment) at Hecla's Apex Site near St. George, Utah. Eight relatively undisturbed samples of Type IV waste materials were successfully collected from various depths within the impoundment. Type IV wastes were the last layer of waste materials placed prior to construction of the temporary cover. Sample test results are summarized in Table 1 below.

<p style="text-align: center;">Table 1 Material Type IV - Laboratory Test Results Summary</p>							
Borehole Number	Sample Depth (ft)	Moisture Content (%)	Liquid Limit	Plastic Limit	Specific Gravity	Permeability (cm/sec)	Percent Passing #200 Sieve
1001-1	5 - 7	107	83	31	3.58	3.7×10^{-6}	99.3
1001-1	8.5 - 9	116	76	21	3.73	NT	93.6
1001-2	5.5	43	NA	NP	3.35	NT	46.7
1001-3	5.5 - 6	52	54	10	3.03	NT	66.1
1001-3	6.5 - 7	62	54	9	3.38	NT	72.5
1001-5	6 - 6.5	104	82	30	3.39	NT	98.5
1001-6	6.5 - 7	114	84	34	3.33	NT	96.3
1001-7	8 - 9	20	27	8	3.11	NT	36.1

NT - not tested

Moisture contents of this waste type ranged from 20% to 116%, and in general increased with depth and distance away from seepage areas located at the outer embankment of the impoundment. Laboratory test results show that Type IV waste is also generally very fine grained as between 36 and 99 percent of the materials are smaller than the #200 sieve. Laboratory permeability of the one remolded sample (borehole 1001-1, 5 to 7 feet) was 3.7×10^{-6} cm/sec, indicating that seepage rates through Type IV materials have been and will continue to be very slow.

Due to the desire to not damage the bottom liner, and some uncertainty in the actual elevation of that liner, Material Types I through III (below Type IV waste materials) were most likely not sampled during the investigation. Although moisture contents of material Types I through III are currently unknown, it is known that Material Type I included tailings and Material Type II included materials pumped into the

impoundment as slurry. Moisture contents of these materials may therefore be relatively high, although they have been and continue to be under much greater consolidation pressure than Material Type IV.

Appendix B

Potential Borrow Source Materials Investigation

Appendix B - Potential Borrow Source Materials Investigation

Summary

Monster Engineering Inc. (MEI) conducted a borrow source materials investigation at Hecla's Apex Site, on surrounding OMG and Shivwits properties, and at other nearby potential material sources from November 13th through 15th, 2002. Table 1 below summarizes material classifications, available quantities, and other information collected at the various potential borrow material sites. Four potentially low-permeability materials and several other potentially acceptable borrow materials were identified for use in the Final Closure Plan for Pond 2.

Table 1 Potential Borrow Materials Summary						
Location	Sample Name	Classification	Estimated Available Volume (cy)	Distance to Site (miles)	Estimated Cost Delivered (per cy)	Materials Owner
Apex Site	Hecla TP-1 Caliche	SM - silty Sand with gravel	1,700	0	\$0	Hecla
Apex Site	Hecla TP-3	CL - sandy lean Clay	8,200	0	\$0	Hecla
Shivwits Land	Shivwits Dam	CL-ML - sandy, silty Clay	11,000	1.5	\$2 + \$ ₁	Shivwits
St. George	Blue Clay	CL/CH - Clay	₂	~13	\$3 ³	various

1 Purchase cost is currently unknown.

2 Availability is dependent on construction activity in St. George (several thousand cy available during November field investigation).

3 Most clay from the St. George area is given away (no cost for material) as it is expansive and not suitable when beneath foundations.

Several additional potential material sources, other than those listed in Table 1, were investigated, sampled, and tested, however materials from these sources were either too coarse grained (high-permeability), too far from the project site (too expensive to purchase and deliver), or had insufficient quantities available.

Limited information concerning topography, soils, vegetation, and drainage was also collected during the field investigation. This information was used during the design of surface water diversion and erosion control facilities.

Background

The primary objective for the investigation was to identify sources, quantities, ownership, and index properties of potentially suitable borrow materials that could be utilized for final reclamation of Hecla's Pond 2. Potential source owners and others potentially knowledgeable of borrow sources included the BLM, the

Utah Department of Transportation (UDOT), private pit operators, construction/excavation contractors, geotechnical materials testing companies, and trucking contractors. Information collected during this initial phase included low-permeability material availability, estimated material and trucking costs, and distance to the site.

Potentially suitable cover materials were determined to be those which could under the correct moisture and compaction conditions achieve a generally low permeability (1×10^{-6} to 1×10^{-8} cm/sec). A low-permeability material was required to achieve the design intent of minimizing infiltration of surface water through the final cover.

Many different potential source sites were inspected to verify material types and available quantities. Small composite bag samples were collected from each source and examined in order to qualitatively compare materials including grain size distribution (potential for achieving low-permeability). The number of potential source sites was then narrowed by utilizing a criteria of reasonable distance to the Apex Site, and therefore reasonable delivery cost, and low-permeability potential (some contacts were overly optimistic).

Seven potential borrow source sites fit the preceding criteria including five off-site sources and two on-site sources. Two of the five off-site sources were located near Gunlock (approximately 10 miles north of the site), two off-site sources were located in and near St. George (between 11 and 13 miles to the site), and the last off-site source was located on Shivwits land about 1.5 miles from the Apex Site. The on-site materials source was located immediately adjacent to and east of Pond 2 on Hecla property. These seven sources were given the following names:

- Gunlock Desert Sage
- Gunlock L & M Clay
- Progressive Number 2
- Blue Clay
- Shivwits Dam
- Hecla TP-1
- Hecla TP-3 Caliche

Off-Site Sources

The potentially most suitable off-site sources were revisited and representative composite samples were collected (5-gallon bucket size) from individual stockpiles for laboratory testing. The only source from which a sample was not collected was the Blue Clay, as the particular material stockpile available for sampling had been excavated from a future home site and was in the process of being shipped off-site for "disposal". According to local soils engineers and a geotechnical testing company, Blue Clay is removed from many different sites in the St. George area. It is expansive (very low permeability) and must be over-excavated when located directly beneath foundations. It is either disposed of, or used in specific projects which require low-permeability materials such as lining ponds or covering disposal areas (landfills).

On-Site Sources

Six test pits were excavated at the Apex Site on Hecla's property immediately east of and adjacent to the impoundment to determine the suitability of the on-site materials. These materials were divided into two separate and distinct layers. Composite 5-gallon bucket samples were collected from each layer for index testing. The first material layer, represented by sample TP-1, was a sandy lean clay that ranged in thickness from 3 to 9 feet, and the second material layer, represented by sample TP-3 Caliche, was a silty sand with gravel that ranged in thickness from 1 to 4 feet. Test pit locations are shown on Figure 1 on the following page, and test pit logs and composite sample locations are shown on the second page following.



Scale 1" = 200'

Hecla Property Boundary/Fence Line

Hecla Pond

TP-1

TP-2

TP-3

TP-4

TP-5

TP-6

Apex - OMG Property

Drainage Channel

Shivwits Property

PROJECT Apex
LOCATION St. George, Utah
DATE 3/25/04

Figure 1
Pond 2 and Test Pit Locations

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Prepared by:



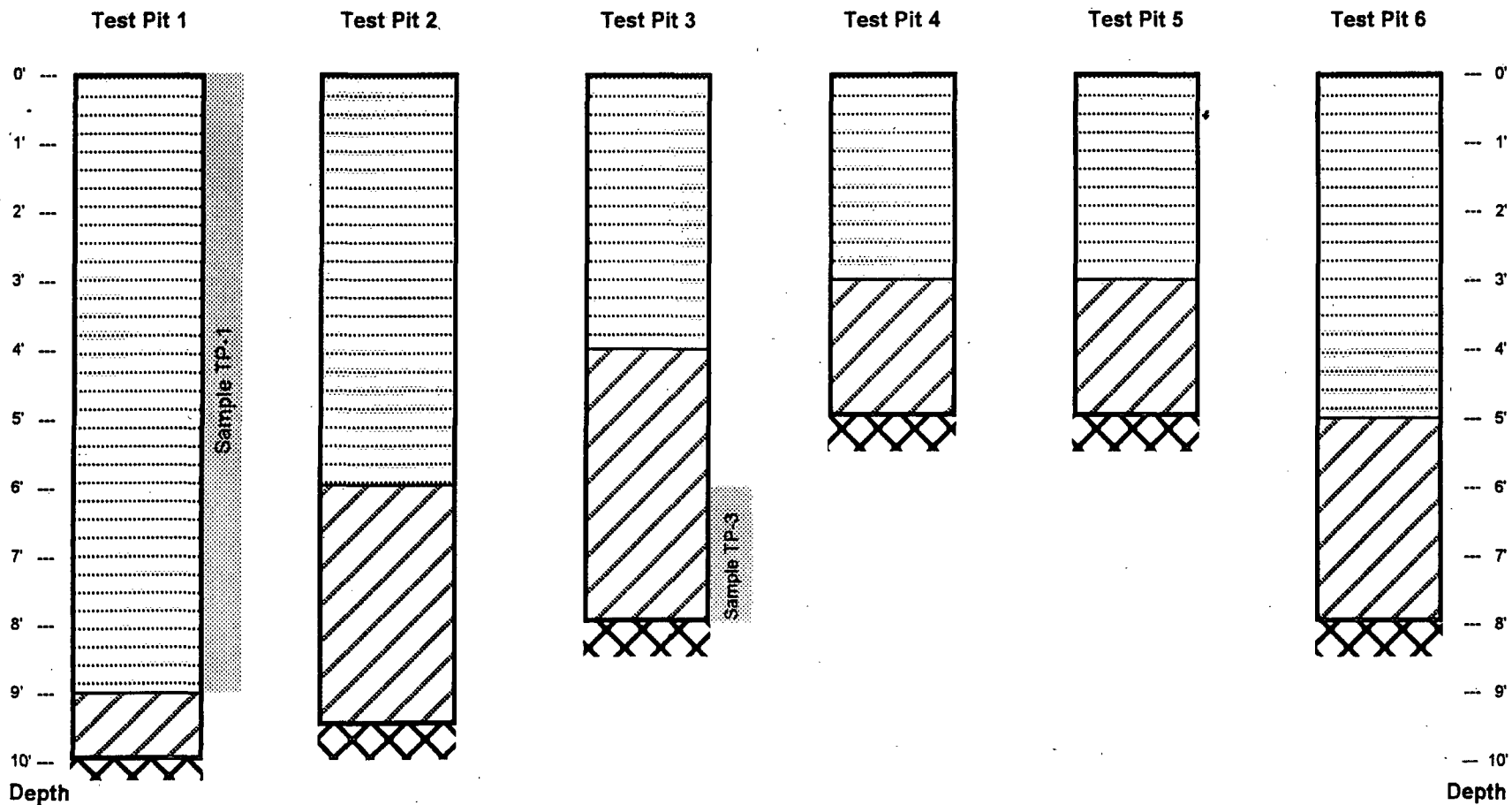
Monster Engineering Inc.

Prepared for:



A00051

Apex Site - Borrow Source Materials Investigation - Test Pit logs



Legend

- (CL) sandy lean Clay
 - (SM) silty Sand with gravel
 - caliche/weathered bedrock



PROJECT APEX Site
 CLIENT Hecla Mining Company
 LOCATION St. George, Utah
 DATE 3/25/04

MONSTER ENGINEERING INC
 ENGINEERING • DESIGN • MANAGEMENT

A000052

Laboratory Testing

All 5-gallon bucket samples were delivered to Applied Geotechnical Engineering Consultants, Inc. (AGEC) in St. George for initial laboratory (index) testing. Testing conducted included:

- natural moisture content
- gradation (including percent passing the #200 sieve)
- Atterberg limits (liquid limit and plasticity index)

Testing results are summarized in Table 2 on the following page. Typical Blue Clay material index properties included in the table were provided by AGEC. Each material's classification is shown on the plasticity chart on the second page following.

Additional laboratory testing (permeability, standard proctors, and optimum moisture content) was completed on three of the seven materials based on index test results. These three materials, Hecla TP-1, Hecla TP-3 Caliche, and Shivwits Dam, had the best potential for utilization as a low-permeability cover in the Final Closure Plan.

Quantities/Estimated Cost Summary

Table 3 on the third page following summarizes test results, available quantities, and estimated costs for each of the seven materials sampled and tested during the field investigation.

Table 2
Apex Site - Borrow Source Materials Investigation - Laboratory Testing Program Summary

Sample Number	Sample Name	Sample Depth	Classification	Natural Moisture Content (%)	Optimum Moisture Content (%)	Gradation Analysis (ASTM D-422)			Liquid Limit	Plasticity Index	Maximum Dry Density (ASTM D-698) (pcf)	Permeability (ASTM D-5084)	Comments
						Percent Gravel	Percent Sand	Percent Passing #200					
1	Gunlock Desert Sage	Grab	SC-SM	4.9		3	68	29	18	4.2			1, 2
2	Hecla TP-3 Caliche	6' - 8'	SM	6.9	14	19	32	49	33	7.4	115.5	1.3x10 ⁻⁵	3
3	Progressive Number 2	Grab	SC	4.7	8.5	18	41	41	23	8.8	127.5		2
4	Gunlock L & M Clay	Grab	CL	5.8		0	36	64	44	21.3			1, 2
5	Hecla TP-1	0' - 9'	CL	4.2	13.5	5	27	68	28	9.7	114.5	2.6x10 ⁻⁶	4
6	Shivwits Dam	Grab	CL-ML	6.2	12	7	32	61	23	5	118.5	6.3x10 ⁻⁶	2
7	Blue Clay	N.A.	CL/CH	8-10	18-20	0	10	90	45-55	20-30	95-105	10 ⁻⁷ /10 ⁻⁸	5

SC-SM = clayey, silty, fine SAND SM = silty SAND with gravel SC = clayey SAND with gravel CL = sandy lean CLAY CL-ML = sandy, silty CLAY

- 1 - Sample not chosen for standard proctor and permeability testing due to better and/or more cost effective materials available.
- 2 - Grab sample was composite collected from many different locations within the pile/location.
- 3 - Sample was a composite of materials from 6' to 8', and is representative of "caliche" type materials at depth in all test pits at site.
- 4 - Sample was a composite of materials from surface to 9', and does not include "caliche" type materials which were encountered at 9'.
- 5 - Results shown are not from a sample collected/tested during MEI's field investigation, but are from similar materials and were provided by Applied Geotechnical Engineering Consultants, Inc. (St. George).



PROJECT APEX Site
 CLIENT Hecla Mining Company
 LOCATION St. George, Utah
 DATE 3/25/04

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Apex Site - Borrow Source Materials Investigation - Potential Cover Soils

Plasticity Chart
(classification of fine-grained soils)

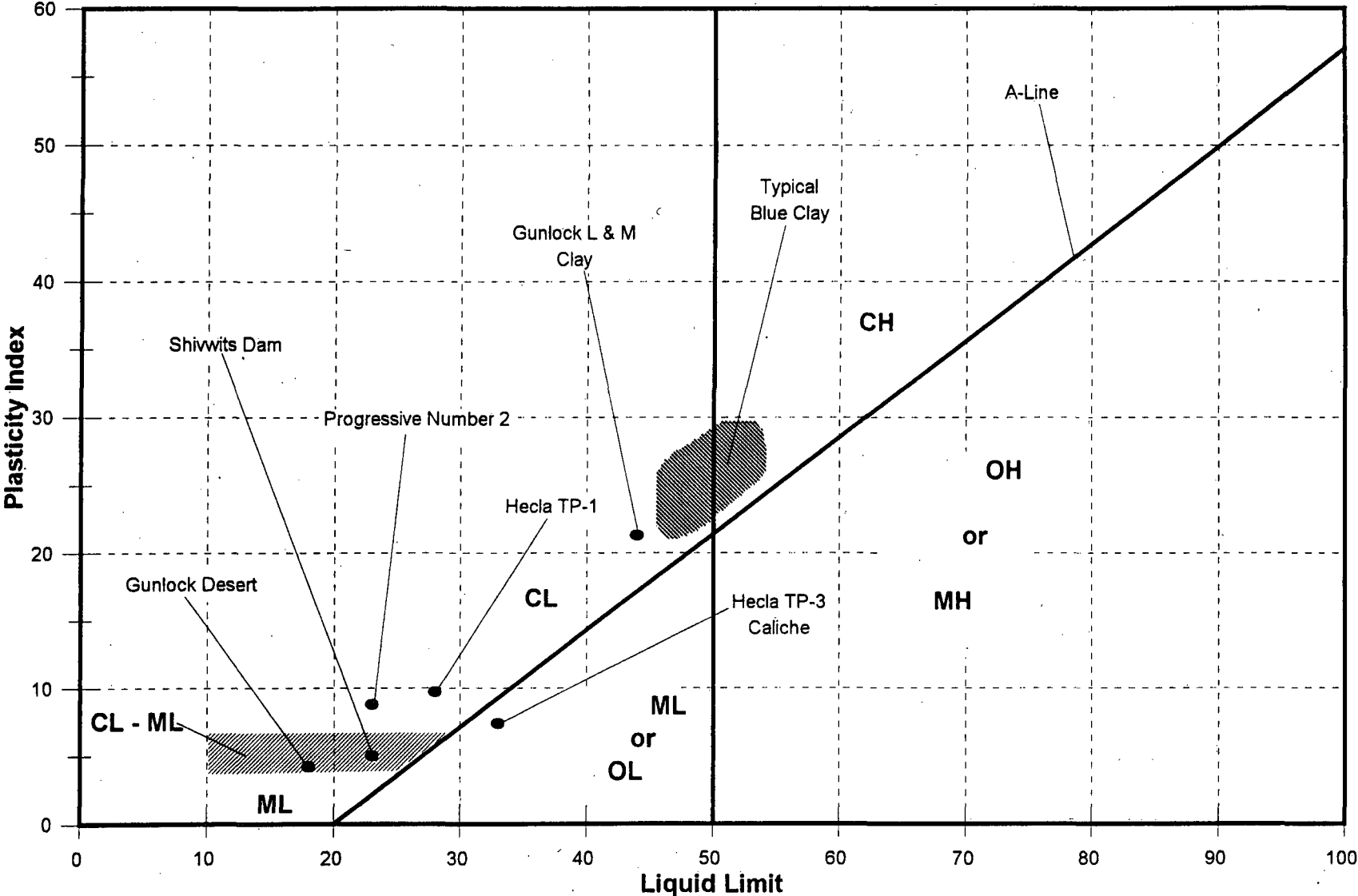


Table 3
Potential Borrow Materials - Summary

Name	Location	Classification / Name	Estimated Available Volume ¹ (cy)	Distance to Site (miles)	Estimated Cost Delivered ² (per cy)	Materials Owner
Gunlock L & M Clay	Gunlock	CL / sandy lean Clay	< 5,000	11.7	\$10 to \$14	Third party to sell to L & M Construction
Gunlock Desert Sage	Gunlock	SC-SM / clayey, silty fine Sand	up to 10,000	10.1	\$8	Gunlock Rock
Progressive Number 2	St. George	SC / clayey Sand with gravel	>> 10,000	13	\$6	Progressive Contracting, Inc.
Blue Clay	St. George (various locations)	CL/CH / Clay	— ³	11- 13	\$3 ⁴	various excavation contractors
Shivwits Dam	Shivwits Land	CL-ML / sandy, silty Clay	11,000	1.5	\$2 + \$— ⁵	Shivwits Band
Hecla TP-1	Hecla Property	CL / sandy lean Clay	8,200	0	\$0	Hecla
Hecla TP-3 Caliche	Hecla Property	SM / silty Sand with gravel	1,700	0	\$0	Hecla

1 It would take approximately 7,300 cubic yards of material to provide a one foot thick foot cover on Pond 2.

2 Estimated Cost Delivered based on 20 tons/load from Gunlock (singles), 40 tons/load from St. George (doubles), \$60/hr trucking costs, 100pcf density, material costs as quoted by each supplier.

3 Quantity available is dependent on construction activity in St. George (several thousand cy were available during the November field investigation).

4 Delivery cost only. Most Blue Clay is given away (no cost for material) as it is expansive and not suitable for beneath foundations.

5 Purchase cost is currently unknown.



Conclusions

Numerous potential borrow materials were examined in order to locate suitable materials for use in the design of the Final Closure Plan for Hecla's Pond 2. Seven potentially acceptable materials (low-permeability) were located, sampled, and submitted for testing. The field of seven potentially acceptable materials was narrowed to four based on field information and laboratory test results.

Rankings of suitability for each of the seven materials tested are shown Table 4 below. Those materials ranked number 5 and lower are most likely not suitable for use as a low-permeability cover. Rankings are qualitative in nature, taking into account available volumes, material cost (purchase and delivery), and potential physical characteristics (permeability).

Table 4 Potential Materials' Suitability Ranking			
Ranking	Material	Positives	Negatives
1	Hecla TP-1	<ul style="list-style-type: none"> No cost to purchase and ship Up to 8,200 cy available Fairly good potential for low permeability (68% passing #200) 	<ul style="list-style-type: none"> Limited supply
2	Shivwits Dam	<ul style="list-style-type: none"> Most likely is OK for low permeability (61% passing #200) Close to site Sufficient quantity (11,000 cy) 	<ul style="list-style-type: none"> Unknown purchase price
3	Hecla TP-3 Caliche	<ul style="list-style-type: none"> No cost to purchase and ship Up to 1,700 cy available Some potential for low permeability (49% passing #200) 	<ul style="list-style-type: none"> Limited supply
4	Blue Clay	<ul style="list-style-type: none"> Good price Most likely the best low permeability material (~90% passing #200) 	<ul style="list-style-type: none"> Available only in piece-meal fashion, unless stockpiled at site over longer period of time
5	Progressive Number 2	<ul style="list-style-type: none"> Sufficient quantity OK price 	<ul style="list-style-type: none"> Too much sand (41%) and gravel (18%) so very likely not a good low permeability material Furthest from site (distance)
6	Gunlock L & M Clay	<ul style="list-style-type: none"> Most likely a good low permeability material (64% passing #200) 	<ul style="list-style-type: none"> Most likely insufficient quantity (<5,000 cy) for cover Highest cost to purchase and deliver Most time to deliver (steep and winding dirt road to borrow area)
7	Gunlock Desert Sage	<ul style="list-style-type: none"> Sufficient quantity 	<ul style="list-style-type: none"> Too much sand (68%) Very likely not a low permeability material High purchase and delivery price

Appendix C
HELP Modeling Results

Appendix C - HELP Modeling Results

Background

Water balance analyses of three closure plan cover system alternatives were performed for Pond 2 at Hecla's Apex facility located near St. George, Utah. The most recent Hydrologic Evaluation of Landfill Performance (HELP) model, version 3.07 (Schroeder 1994a and 1994b) (UASCE 1997) was utilized as the analytical model. The HELP model is a quasi-two-dimensional hydrologic model which accounts for effects of:

- ▶ surface water storage
- ▶ snowmelt
- ▶ runoff
- ▶ infiltration
- ▶ evapotranspiration
- ▶ vegetative growth
- ▶ soil moisture storage
- ▶ lateral subsurface drainage
- ▶ unsaturated vertical drainage
- ▶ various soil covers

The model was developed specifically to conduct water balance analyses of landfills, cover systems, and solid waste disposal / containment facilities and assists in comparison of design alternatives.

It is noted that research has shown that HELP overestimates vertical moisture flux (percolation) in arid and semi-arid climates as it does not closely account for capillary forces and does not allow for removal of water from below the soil evaporative zone (Fleenor and King 1995). As climate conditions become increasingly arid, consistently greater over-prediction of vertical moisture flux occurs in the model. Therefore, actual percolation at the Apex Site will likely be significantly less than those shown through this modeling effort, and HELP results shown here should only be utilized for comparison of different cover system alternatives.

The Final Closure Plan cover alternatives that were evaluated are listed in Table 1 on the following page. Hecla's selected alternative for the Final Closure Plan is listed as GCL (number 2).

<p>Table 1 Conceptual Closure Plan Alternatives</p>			
Cover System Layer	Alternative		
	1 Blue Clay (CCL)	2 GCL	3 On-Site Materials I
Surface	6" rock (outslopes only)	6" rock (outslopes only)	6" rock (outslopes only)
Protection	12" on-site soils TP-1 (2.6×10^{-6} cm/sec)	12" on-site soils TP-1 (2.6×10^{-6} cm/sec)	12" soils Shivwit's Dam (6.3×10^{-6} cm/sec)
Barrier	12" Blue Clay (10^{-7} to 10^{-8} cm/sec)	GCL (5×10^{-9} cm/sec)	12" on-site soils TP-1 (2.6×10^{-6} cm/sec)

HELP Model - Soil Layer Information

The HELP model includes a database of default soil types. Information listed for each default soil type includes:

- ▶ description (either USDA and USCS or material type)
- ▶ porosity
- ▶ field-capacity
- ▶ wilting point
- ▶ saturated hydraulic conductivity

Little site-specific moisture retention data exists, therefore default HELP soil types were selected based on the results of existing site-specific field sampling and laboratory testing. Values for each variable for each cover system analyzed are listed in Table 2 on the following page.

Table 2 HELP Model Default Soil Types - Cover System Alternatives			
Cover System Variable	Alternative		
	1 Blue Clay (CCL)	2 GCL	3 On-Site Materials I
Layer 1 – Surface (Vertical Percolation)			
Depth	8"	8"	8"
HELP Soil Type	#21 (gravel)	#21 (gravel)	#21 (gravel)
Saturated Hyd. Cond. ¹	3.0×10^{-1} cm/sec	3.0×10^{-1} cm/sec	3.0×10^{-1} cm/sec
Porosity (vol/vol)	0.397	0.397	0.397
Field Capacity (v/v) ²	0.032	0.032	0.032
Wilting Point (v/v) ³	0.013	0.013	0.013
Layer 2 – Protection (Lateral Drainage)			
Distance	300 feet	300 feet	300 feet
Slope	1%	1%	1%
Depth	12"	12"	12"
HELP Soil Type	#25 (CL comp. ⁴)	#25 (CL comp.)	#23 (ML comp.)
Saturated Hyd. Cond.	3.6×10^{-6} cm/sec	3.6×10^{-6} cm/sec	9.0×10^{-6} cm/sec
Porosity (vol/vol)	0.437	0.437	0.461
Field Capacity (v/v)	0.373	0.373	0.360
Wilting Point (v/v)	0.266	0.266	0.203
Layer 3 – Barrier (Barrier Soil)			
Depth	12"	0.25"	12"
HELP Soil Type	#16 (barrier soil)	#17 (bentonite mat)	#25 (CL comp.)
Saturated Hyd. Cond.	1.0×10^{-7} cm/sec	3.0×10^{-9} cm/sec	3.6×10^{-6} cm/sec
Porosity (vol/vol)	0.427	0.750	0.437
Field Capacity (v/v)	0.418	0.747	0.373
Wilting Point (v/v)	0.367	0.400	0.266

1 - Saturated Hyd. Cond. = saturated hydraulic conductivity

2 - Field Capacity = moisture content at -1/3 bar

3 - Wilting Point = moisture content at -15 bars

4 - comp. = compacted

During initial HELP model runs, the program was utilized to calculate a Soil Conservation Service (SCS) curve number (89). For subsequent model runs, the curve number was set at 70. A curve number of 70 is analogous to pasture or range in poor condition and hydrologic soil group A. Group A soils have low total surface runoff potential due to high infiltration rates even when thoroughly wetted.

Climate

In order to provide climate data for the HELP model, a climate file was created from default data adjusted to site-specific values. A 5-year climate database was developed based on utilizing HELP's internal default information from its nearest climate station (Cedar City, Utah). This data was then adjusted for the

climate data station (Lytle Ranch, Utah) nearest to the site. In particular the following data was utilized as input:

- ▶ Synthetic Precipitation - The input average annual precipitation was a conservative 10.71 inches which is significantly higher than St. George's average annual rainfall of 8.3 inches.
- ▶ Synthetic Temperature
- ▶ Synthetic Solar Radiation – Latitude was adjusted from 37.5 degrees to 37.1 degrees.
- ▶ Evaporative Zone Depth – Depth was set to default value for Cedar City (16 inches).
- ▶ Leaf Area Index – Index was set to zero for bare ground conditions.

A summary of daily temperature values and average annual precipitation for selected climate stations and values used in the HELP model is provided in Table 3 below.

<p>Table 3 Summary of Temperature and Precipitation Data</p>								
Month	St. George, Utah ¹			Lytle Ranch, Utah ²			HELP Model ³	
	Daily Max. Temp (F)	Daily Min. Temp (F)	Avg. Precip. (inches)	Daily Max. Temp. (F)	Daily Min. Temp. (F)	Avg. Precip. (inches)	Average Daily Temp. (F)	Average Precipitation (inches)
Jan	53.5	25.6	1.09	56.9	29.0	1.71	43.0	1.71
Feb	60.0	30.4	0.99	61.0	33.1	2.03	47.1	2.03
Mar	67.8	36.0	0.94	68.0	37.5	1.74	52.8	1.74
Apr	76.7	42.8	0.51	76.7	42.0	0.60	59.4	0.60
May	86.0	50.9	0.40	85.2	49.0	0.52	67.1	0.52
Jun	96.1	58.9	0.19	94.5	55.2	0.35	74.9	0.35
Jul	101.6	66.3	0.68	100.7	60.6	0.65	80.7	0.65
Aug	99.5	65.0	0.77	99.7	60.0	0.74	79.9	0.74
Sep	92.6	55.1	0.62	92.4	52.4	0.73	72.4	0.73
Oct	80.2	43.0	0.68	80.3	41.6	0.64	61.0	0.64
Nov	64.9	31.8	0.63	65.6	31.6	0.65	48.6	0.65
Dec	54.0	25.7	0.77	57.3	26.5	0.36	41.9	0.36
Annual	77.7	44.3	8.27	78.2	43.2	10.71	--	--

1 St. George station operational from 1892 to 2001.

2 Lytle Ranch operational from 1988 to 2001 (WRCC, 2003).

3 HELP model precipitation and average daily temperature are from Lytle Ranch. Average daily temperature is the average of daily minimum and maximum values.

HELP Modeling Summary

The latest version (3.07) of the HELP model was utilized to evaluate three cover system alternatives. Results are summarized in Table 4 below.

Table 4 HELP Modeling Results Summary Average Annual Totals - Years 1 to 5			
Calculated HELP Values	Alternative		
	1 Blue Clay (CCL)	2 GCL	3 On-Site Materials I
Precipitation (inches/year)	10.82	10.82	10.82
Runoff (inches/year)	0.00	0.00	0.00
Evapotranspiration (inches/year)	10.06	10.08	10.49
Lateral Drainage Collected from Layer 2 (inches/year)	0.0565	0.1134	0.0000
Percolation/Leakage through layer 3 (inches/year)	0.62456	0.51796	0.22851
Average head on top of layer 3 (inches)	1.473	3.250	0.001
Change in water storage (inches)	0.083	0.112	0.103

Results from the HELP modeling show that:

- ▶ All three cover alternatives have very low and similar percolation rates, although comparatively, Alternative 3 would allow significantly less percolation than Alternatives 1 and 2.
- ▶ Alternatives 1 and 2 (Blue Clay and GCL) would have essentially the same percolation rates.
- ▶ Increases in water storage values would be nearly equivalent for all three alternatives.
- ▶ Total available water storage (the difference between field capacity and wilting point multiplied by the layer thickness) in the lower two (soil) layers for Alternatives 1 and 2 would be very similar. Total available water storage for Alternative 3 would be significantly higher as the Barrier Layer for Alternative 3 consists of a 12-inch thick layer of soil with a relatively open soil structure.
- ▶ Alternative 3 (On-Site Materials I) has the lowest percolation rate through the Barrier Layer, again due to the open soil structure and higher total available water storage capacity. The Barrier Layer for Alternative 3 consists of a 12-inch thick layer of soil type #25 (USCS type CL). The Barrier Layers for

Alternatives 1 and 2 consist of 12-inches of Blue Clay alternative and 0.25-inches of "Bentonite Mat", each of which has significantly less water storage capacity.

- ▶ Alternative 3 (On-Site Materials I) has the lowest average annual infiltration value (highest evapotranspiration). This is also due to the greater available water storage of the Barrier Layer material in this alternative.

Complete HELP modeling outputs are included after the References section.

References

Fleenor and King 1995. Fleenor, W. E., and King, I. P. Identifying Limitations on Use of HELP Model, Landfill Closures: Environmental Protection and Land Recovery, Special Publication #53, ASCE, Dunn, R. J. and Singh, U. P. editors.

Schroeder 1994a. Schroeder, P.R., Lloyd, C.M., and Zappi, P.A. The Hydrologic Evaluation of Landfill Performance (HELP) Model User's Guide for Version 3, EPA/600/R-94/168a, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

Schroeder 1994b. Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjoström, J.W., and Peyton, R.L. The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3, EPA/600/R-94/168b, U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

USACE 1997. U.S. Army Corps of Engineers. Hydrologic Evaluation of Landfill Performance, Version 3.07. Environmental Laboratory, Waterways Experiment Station, Vicksburg, Mississippi 39180.

WRCC 2003. Western Regional Climate Center. Historical Climate Information, Desert Research Institute, Reno, Nevada. www.wrcc.dri.edu

HELP Output

Alternative Cover System 1

Blue Clay

```

*****
*****
**
**
**
**      HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE      **
**      HELP MODEL VERSION 3.07 (1 NOVEMBER 1997)          **
**      DEVELOPED BY ENVIRONMENTAL LABORATORY              **
**      USAE WATERWAYS EXPERIMENT STATION                 **
**      FOR USEPA RISK REDUCTION ENGINEERING LABORATORY    **
**
**
*****
*****

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TEMPERATURE DATA FILE:   C:\EPAHELPV\DATA7.D7
SOLAR RADIATION DATA FILE: C:\EPAHELPV\DATA13.D13
EVAPOTRANSPIRATION DATA:  C:\EPAHELPV\DATA11.D11
SOIL AND DESIGN DATA FILE: C:\EPAHELPV\BLUECLAY.D10
OUTPUT DATA FILE:         C:\EPAHELPV\blueclay.OUT

```

TIME: 11:51 DATE: 3/30/2003

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*****
**      TITLE:  APEX Cover Evaluation Blue Clay      **
*****

```

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 21

THICKNESS	=	8.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0273	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 25

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.3730	VOL/VOL
WILTING POINT	=	0.2660	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3232	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.359999990000E-05	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS = 12.00 INCHES
POROSITY = 0.4270 VOL/VOL
FIELD CAPACITY = 0.4180 VOL/VOL
WILTING POINT = 0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4270 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER = 70.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 5.700 ACRES
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE = 2.604 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE = 6.672 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE = 2.232 INCHES
INITIAL SNOW WATER = 0.000 INCHES
INITIAL WATER IN LAYER MATERIALS = 9.220 INCHES
TOTAL INITIAL WATER = 9.220 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CEDAR CITY UTAH

STATION LATITUDE = 37.10 DEGREES
MAXIMUM LEAF AREA INDEX = 0.00
START OF GROWING SEASON (JULIAN DATE) = 125
END OF GROWING SEASON (JULIAN DATE) = 284
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 36.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 34.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 58.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MILFORD UTAH

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
1.71	2.03	1.74	0.60	0.52	0.35
0.65	0.74	0.73	0.64	0.65	0.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.00	47.10	52.80	59.40	67.10	74.90
80.70	79.90	72.40	61.00	48.60	41.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH
AND STATION LATITUDE = 37.10 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.97	185598.281	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.504	175961.437	94.81
DRAINAGE COLLECTED FROM LAYER 2	0.0001	1.548	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.268053	5546.291	2.99
AVG. HEAD ON TOP OF LAYER 3	0.3012		
CHANGE IN WATER STORAGE	0.198	4089.082	2.20
SOIL WATER AT START OF YEAR	9.220	190774.594	
SOIL WATER AT END OF YEAR	9.418	194863.672	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.074	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.03	248912.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.725	221906.250	89.15
DRAINAGE COLLECTED FROM LAYER 2	0.2813	5820.932	2.34
PERC./LEAKAGE THROUGH LAYER 3	0.903545	18695.254	7.51
AVG. HEAD ON TOP OF LAYER 3	2.6175		
CHANGE IN WATER STORAGE	0.120	2490.317	1.00

SOIL WATER AT START OF YEAR	9.418	194863.672	
SOIL WATER AT END OF YEAR	9.538	197353.984	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.70	242084.672	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.706	221513.750	91.50
DRAINAGE COLLECTED FROM LAYER 2	0.0005	11.036	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.958710	19836.670	8.19
AVG. HEAD ON TOP OF LAYER 3	2.1747		
CHANGE IN WATER STORAGE	0.035	723.235	0.30
SOIL WATER AT START OF YEAR	9.538	197353.984	
SOIL WATER AT END OF YEAR	9.573	198077.219	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.035	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.17	169045.531	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.029	166119.531	98.27
DRAINAGE COLLECTED FROM LAYER 2	0.0001	1.865	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.291976	6041.267	3.57
AVG. HEAD ON TOP OF LAYER 3	0.3601		
CHANGE IN WATER STORAGE	-0.151	-3117.139	-1.84
SOIL WATER AT START OF YEAR	9.573	198077.219	

SOIL WATER AT END OF YEAR	9.422	194960.078	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.002	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.25	274155.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.336	255251.297	93.10
DRAINAGE COLLECTED FROM LAYER 2	0.0005	9.708	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.700508	14494.208	5.29
AVG. HEAD ON TOP OF LAYER 3	1.9112		
CHANGE IN WATER STORAGE	0.213	4400.559	1.61
SOIL WATER AT START OF YEAR	9.422	194960.078	
SOIL WATER AT END OF YEAR	9.635	199360.641	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	1.42 0.60	1.55 0.79	1.41 1.25	0.81 0.49	0.75 1.00	0.39 0.35
STD. DEVIATIONS	0.93 0.52	0.83 0.40	0.52 0.73	0.45 0.45	0.59 0.61	0.09 0.21
RUNOFF						

TOTALS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATIONS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION						

TOTALS	0.901 0.654	1.437 0.619	1.320 1.156	1.113 0.678	0.718 0.670	0.355 0.439
STD. DEVIATIONS	0.555 0.599	0.431 0.305	0.805 0.591	0.647 0.349	0.571 0.569	0.159 0.213
LATERAL DRAINAGE COLLECTED FROM LAYER 2						

TOTALS	0.0122 0.0000	0.0008 0.0000	0.0001 0.0000	0.0001 0.0000	0.0000 0.0433	0.0000 0.0000
STD. DEVIATIONS	0.0272 0.0000	0.0016 0.0000	0.0001 0.0000	0.0000 0.0000	0.0000 0.0968	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 3						

TOTALS	0.0363 0.0045	0.0833 0.0013	0.1107 0.0112	0.1082 0.0457	0.0888 0.0541	0.0401 0.0403
STD. DEVIATIONS	0.0635 0.0082	0.0786 0.0011	0.0739 0.0215	0.0609 0.0632	0.0536 0.0720	0.0504 0.0641

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 3						

AVERAGES	1.2734 0.0051	4.0184 0.0001	4.0560 0.1198	3.0650 0.6888	1.2671 1.7967	0.3041 1.0806
STD. DEVIATIONS	2.0605 0.0112	3.8876 0.0001	3.3014 0.2672	2.4168 1.2071	1.2680 3.2751	0.4968 2.3619

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.82 (2.156)	223959.4	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	10.060 (1.7740)	208150.47	92.941
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.05650 (0.12568)	1169.018	0.52198
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.62456 (0.32900)	12922.737	5.77012
AVERAGE HEAD ON TOP OF LAYER 3	1.473 (1.073)		
CHANGE IN WATER STORAGE	0.083 (0.1485)	1717.21	0.767

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	0.97	20070.270
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.05849	1210.12781
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.007081	146.51971
AVERAGE HEAD ON TOP OF LAYER 3	12.982	
MAXIMUM HEAD ON TOP OF LAYER 3	15.989	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	124.1 FEET	
SNOW WATER	0.08	1661.7969
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.2731
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1397

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

A00072

FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.1163	0.0145
2	4.3948	0.3662
3	5.1240	0.4270
SNOW WATER	0.000	

HELP Output

Alternative Cover System 2

GCL

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS = 0.25 INCHES
POROSITY = 0.7500 VOL/VOL
FIELD CAPACITY = 0.7470 VOL/VOL
WILTING POINT = 0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.7500 VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.300000003000E-08 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER = 70.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 5.700 ACRES
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE = 2.604 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE = 6.672 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE = 2.232 INCHES
INITIAL SNOW WATER = 0.000 INCHES
INITIAL WATER IN LAYER MATERIALS = 4.284 INCHES
TOTAL INITIAL WATER = 4.284 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CEDAR CITY UTAH

STATION LATITUDE = 37.10 DEGREES
MAXIMUM LEAF AREA INDEX = 0.00
START OF GROWING SEASON (JULIAN DATE) = 125
END OF GROWING SEASON (JULIAN DATE) = 284
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 36.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 34.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 58.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MILFORD UTAH

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.71	2.03	1.74	0.60	0.52	0.35
0.65	0.74	0.73	0.64	0.65	0.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.00	47.10	52.80	59.40	67.10	74.90
80.70	79.90	72.40	61.00	48.60	41.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH
AND STATION LATITUDE = 37.10 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.97	185598.281	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.504	175961.437	94.81
DRAINAGE COLLECTED FROM LAYER 2	0.0003	7.089	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.237115	4906.151	2.64
AVG. HEAD ON TOP OF LAYER 3	1.3743		
CHANGE IN WATER STORAGE	0.228	4723.678	2.55
SOIL WATER AT START OF YEAR	4.284	88633.469	
SOIL WATER AT END OF YEAR	4.512	93357.148	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.072	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.03	248912.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.725	221906.250	89.15
DRAINAGE COLLECTED FROM LAYER 2	0.4008	8292.013	3.33
PERC./LEAKAGE THROUGH LAYER 3	0.664916	13757.773	5.53
AVG. HEAD ON TOP OF LAYER 3	4.2542		
CHANGE IN WATER STORAGE	0.240	4956.729	1.99
SOIL WATER AT START OF YEAR	4.512	93357.148	

SOIL WATER AT END OF YEAR	4.752	98313.875	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.70	242084.672	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.754	222504.437	91.91
DRAINAGE COLLECTED FROM LAYER 2	0.1034	2138.912	0.88
PERC./LEAKAGE THROUGH LAYER 3	0.771793	15969.175	6.60
AVG. HEAD ON TOP OF LAYER 3	4.9517		
CHANGE IN WATER STORAGE	0.071	1472.181	0.61
SOIL WATER AT START OF YEAR	4.752	98313.875	
SOIL WATER AT END OF YEAR	4.823	99786.062	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.048	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.17	169045.531	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.031	166173.187	98.30
DRAINAGE COLLECTED FROM LAYER 2	0.0004	9.214	0.01
PERC./LEAKAGE THROUGH LAYER 3	0.304574	6301.935	3.73
AVG. HEAD ON TOP OF LAYER 3	1.7875		
CHANGE IN WATER STORAGE	-0.166	-3438.768	-2.03
SOIL WATER AT START OF YEAR	4.823	99786.062	

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SOIL WATER AT END OF YEAR	4.656	96347.289	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.043	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.25	274155.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.388	256318.766	93.49
DRAINAGE COLLECTED FROM LAYER 2	0.0622	1287.427	0.47
PERC./LEAKAGE THROUGH LAYER 3	0.611392	12650.315	4.61
AVG. HEAD ON TOP OF LAYER 3	3.8823		
CHANGE IN WATER STORAGE	0.188	3899.275	1.42
SOIL WATER AT START OF YEAR	4.656	96347.289	
SOIL WATER AT END OF YEAR	4.845	100246.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.005	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	1.42 0.60	1.55 0.79	1.41 1.25	0.81 0.49	0.75 1.00	0.39 0.35
STD. DEVIATIONS	0.93 0.52	0.83 0.40	0.52 0.73	0.45 0.45	0.59 0.61	0.09 0.21
RUNOFF						

TOTALS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATIONS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION						

TOTALS	0.901 0.654	1.440 0.619	1.329 1.160	1.115 0.678	0.719 0.670	0.355 0.439
STD. DEVIATIONS	0.555 0.600	0.431 0.305	0.815 0.597	0.648 0.349	0.572 0.569	0.160 0.213
LATERAL DRAINAGE COLLECTED FROM LAYER 2						

TOTALS	0.0202 0.0000	0.0185 0.0000	0.0088 0.0000	0.0037 0.0001	0.0001 0.0619	0.0001 0.0001
STD. DEVIATIONS	0.0357 0.0000	0.0367 0.0000	0.0194 0.0000	0.0081 0.0000	0.0000 0.1383	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 3						

TOTALS	0.0403 0.0304	0.0646 0.0254	0.0692 0.0255	0.0592 0.0357	0.0451 0.0479	0.0351 0.0394
STD. DEVIATIONS	0.0387 0.0119	0.0474 0.0098	0.0442 0.0139	0.0300 0.0187	0.0193 0.0381	0.0134 0.0266

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	2.9841 2.1547	5.4253 1.7561	5.2299 1.8342	4.5860 2.5742	3.3172 3.6578	2.6154 2.8651
STD. DEVIATIONS	2.9947 0.9373	4.1050 0.7738	3.4790 1.1315	2.4461 1.4790	1.5265 3.1117	1.0933 2.1034

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	10.82 (2.156)	223959.4	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	10.080 (1.7942)	208572.83	93.130
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.11343 (0.16646)	2346.931	1.04793
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.51796 (0.23407)	10717.069	4.78527
AVERAGE HEAD ON TOP OF LAYER 3	3.250 (1.578)		
CHANGE IN WATER STORAGE	0.112 (0.1693)	2322.62	1.037

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	0.97	20070.270
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.07468	1545.21692
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.005510	114.00568
AVERAGE HEAD ON TOP OF LAYER 3	13.249	
MAXIMUM HEAD ON TOP OF LAYER 3	16.286	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	125.2 FEET	
SNOW WATER	0.08	1661.7969
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.2798
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1397

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

A000081

FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.1163	0.0145
2	4.5411	0.3784
3	0.1875	0.7500
SNOW WATER	0.000	

HELP Output

Alternative Cover System 3

On-Site Materials I

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**
**      HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
**      HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)
**      DEVELOPED BY ENVIRONMENTAL LABORATORY
**      USAE WATERWAYS EXPERIMENT STATION
**      FOR USEPA RISK REDUCTION ENGINEERING LABORATORY
**
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PRECIPITATION DATA FILE:  C:\EPAHELPV\DATA4.D4
TEMPERATURE DATA FILE:   C:\EPAHELPV\DATA7.D7
SOLAR RADIATION DATA FILE: C:\EPAHELPV\DATA13.D13
EVAPOTRANSPIRATION DATA:  C:\EPAHELPV\DATA11.D11
SOIL AND DESIGN DATA FILE: C:\EPAHELPV\ONSITE.D10
OUTPUT DATA FILE:        C:\EPAHELPV\onsite.OUT

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TIME: 11:58 DATE: 3/30/2003

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*****
TITLE: APEX Cover Evaluation On-Site Materials Alternative
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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 21

THICKNESS	=	8.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0241	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 23

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2736	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER MATERIAL TEXTURE NUMBER 25

THICKNESS = 12.00 INCHES
POROSITY = 0.4370 VOL/VOL
FIELD CAPACITY = 0.3730 VOL/VOL
WILTING POINT = 0.2660 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.4370 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.359999990000E-05 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER = 70.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 5.700 ACRES
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
INITIAL WATER IN EVAPORATIVE ZONE = 2.036 INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE = 6.864 INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE = 1.728 INCHES
INITIAL SNOW WATER = 0.000 INCHES
INITIAL WATER IN LAYER MATERIALS = 8.720 INCHES
TOTAL INITIAL WATER = 8.720 INCHES
TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
CEDAR CITY UTAH

STATION LATITUDE = 37.10 DEGREES
MAXIMUM LEAF AREA INDEX = 0.00
START OF GROWING SEASON (JULIAN DATE) = 125
END OF GROWING SEASON (JULIAN DATE) = 284
EVAPORATIVE ZONE DEPTH = 16.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 64.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 36.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 34.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 58.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR MILFORD UTAH

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.71	2.03	1.74	0.60	0.52	0.35
0.65	0.74	0.73	0.64	0.65	0.36

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
43.00	47.10	52.80	59.40	67.10	74.90
80.70	79.90	72.40	61.00	48.60	41.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR CEDAR CITY UTAH
AND STATION LATITUDE = 37.10 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.97	185598.281	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.886	183852.016	99.06
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.002411	49.878	0.03
AVG. HEAD ON TOP OF LAYER 3	0.0000		
CHANGE IN WATER STORAGE	0.082	1696.401	0.91
SOIL WATER AT START OF YEAR	8.720	180416.891	
SOIL WATER AT END OF YEAR	8.802	182113.297	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.03	248912.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.364	235129.812	94.46
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.036	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.807184	16701.451	6.71
AVG. HEAD ON TOP OF LAYER 3	0.0035		

CHANGE IN WATER STORAGE	-0.141	-2918.591	-1.17
SOIL WATER AT START OF YEAR	8.802	182113.297	
SOIL WATER AT END OF YEAR	8.661	179194.703	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.059	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.70	242084.672	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	11.140	230502.172	95.22
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.018862	390.266	0.16
AVG. HEAD ON TOP OF LAYER 3	0.0001		
CHANGE IN WATER STORAGE	0.541	11192.160	4.62
SOIL WATER AT START OF YEAR	8.661	179194.703	
SOIL WATER AT END OF YEAR	9.201	190386.875	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.062	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.17	169045.531	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	8.408	173965.109	102.91
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.008979	185.785	0.11

AVG. HEAD ON TOP OF LAYER 3	0.0000		
CHANGE IN WATER STORAGE	-0.247	-5105.501	-3.02
SOIL WATER AT START OF YEAR	9.201	190386.875	
SOIL WATER AT END OF YEAR	8.955	185281.359	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.135	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.25	274155.781	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	12.666	262068.219	95.59
DRAINAGE COLLECTED FROM LAYER 2	0.0000	0.004	0.00
PERC./LEAKAGE THROUGH LAYER 3	0.305118	6313.189	2.30
AVG. HEAD ON TOP OF LAYER 3	0.0010		
CHANGE IN WATER STORAGE	0.279	5774.373	2.11
SOIL WATER AT START OF YEAR	8.955	185281.359	
SOIL WATER AT END OF YEAR	9.234	191055.734	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.006	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	1.42 0.60	1.55 0.79	1.41 1.25	0.81 0.49	0.75 1.00	0.39 0.35
STD. DEVIATIONS	0.93 0.52	0.83 0.40	0.52 0.73	0.45 0.45	0.59 0.61	0.09 0.21
RUNOFF						

TOTALS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
STD. DEVIATIONS	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
EVAPOTRANSPIRATION						

TOTALS	0.824 0.624	1.537 0.707	1.553 1.208	0.983 0.641	0.733 0.740	0.386 0.558
STD. DEVIATIONS	0.568 0.650	0.477 0.470	0.983 0.638	0.544 0.283	0.442 0.631	0.177 0.188
LATERAL DRAINAGE COLLECTED FROM LAYER 2						

TOTALS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
STD. DEVIATIONS	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 3						

TOTALS	0.0138 0.0010	0.1012 0.0004	0.0113 0.0003	0.0018 0.0000	0.0010 0.0961	0.0015 0.0001
STD. DEVIATIONS	0.0299 0.0009	0.1381 0.0005	0.0209 0.0005	0.0021 0.0000	0.0011 0.2139	0.0027 0.0002

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)						

DAILY AVERAGE HEAD ON TOP OF LAYER 3						

AVERAGES	0.0003 0.0001	0.0038 0.0000	0.0005 0.0000	0.0001 0.0000	0.0001 0.0061	0.0001 0.0000
STD. DEVIATIONS	0.0005 0.0000	0.0052 0.0000	0.0009 0.0000	0.0002 0.0000	0.0001 0.0135	0.0002 0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	10.82	(2.156)	223959.4	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	10.493	(1.7910)	217103.47	96.939
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.00000	(0.00000)	0.008	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.22851	(0.34785)	4728.114	2.11115
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
CHANGE IN WATER STORAGE	0.103	(0.3182)	2127.77	0.950

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	0.97	20070.270
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 2	0.00000	0.01386
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.126475	2616.90039
AVERAGE HEAD ON TOP OF LAYER 3	0.394	
MAXIMUM HEAD ON TOP OF LAYER 3	0.738	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	19.1 FEET	
SNOW WATER	0.08	1661.7969
MAXIMUM VEG. SOIL WATER (VOL/VOL)		0.2446
MINIMUM VEG. SOIL WATER (VOL/VOL)		0.1103

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	0.1161	0.0145
2	3.8736	0.3228
3	5.2440	0.4370
SNOW WATER	0.000	

Appendix D
Vertical Wick Drain Analyses

Appendix D - Vertical Wick Drain Analyses

Background

Vertical wick drains are to be installed through the temporary cover materials and into the waste materials within Hecla's Pond 2 at the Apex Site. Analyses of the waste material's flow characteristics and the corresponding consolidation time were conducted to determine the estimated optimum spacing (quantity of drains) to be installed. Vertical drains facilitate the dewatering / consolidation process by providing a shorter and much higher permeability conduit for fluid flow from the waste materials. Providing for drainage / consolidation prior to final cover placement will minimize potential future settlement and long-term damage to the final cover system.

Method of Analysis

Optimum drain spacing is dependent on the flow characteristics of each material to be drained, which is primarily determined by that material's coefficient of horizontal flow (C_h) measured in m^2/sec . Additional factors for determining optimum drain spacing are:

- U = average degree of consolidation (%)
- t = the desired consolidation time

both of which are selected by the designer.

For these analyses the average degree of consolidation was selected as 90% and a range of times from 1 to 4 months was selected in which to achieve 90% consolidation.

Calculation of C_h

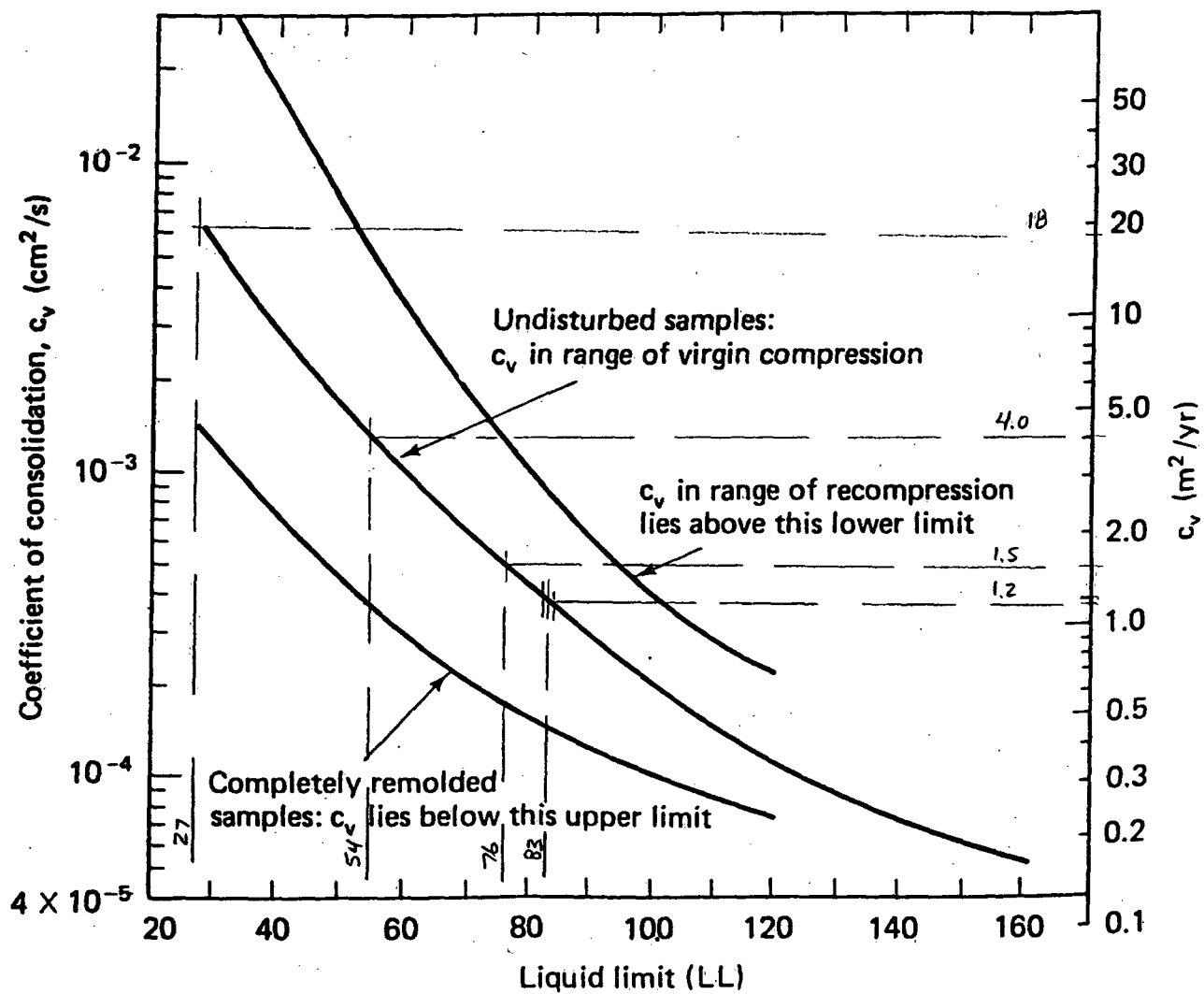
Ideally C_h is determined in the laboratory by first testing for and calculating the coefficient of vertical consolidation (C_v) from undisturbed material samples, then correlating the tested C_v value to a C_h value. Typically C_h ranges from 1 to 5 times the C_v value (Bowles 1982, NILEX 2003). At the Apex site C_v could not be determined in the laboratory as waste materials from the impoundment contained significant quantities of fine grained materials and fluids (see Table 1 on the following page).

Table 1 Waste Material Field and Laboratory Testing Data					
Bore Hole	Sample Number	Sample Depth (ft)	Moisture Content (%)	Percent Passing #200 Sieve	Liquid Limit
1	1	5 - 7	107.0	99.3	83
1	2	8.5 - 9	115.7	93.6	76
3	4	5.5 - 6	52.1	66.1	54
3	5	6.5 - 7	61.8	72.5	54
5	6	6 - 6.5	103.9	98.5	82
6	7	6.5 - 7	114.0	96.3	84
7	8	8 - 9	20.1	36.1	27

These very wet, high fines waste material samples could not be successfully sampled, transported, and have accurate laboratory consolidation tests conducted as significant remolding of the samples occurred between extraction from the impoundment and receipt at the laboratory. Therefore to determine C_v , a range of values was estimated by utilizing correlations between a known material characteristic (liquid limit) and C_v (U.S. Navy 1971) (Holtz and Kovacs 1981). The correlation chart between liquid limit values and C_v values is shown on the following page.

Based on the amount of coarse grained materials placed into the impoundment during clean-up activities (SMI 2001), a value of 3.5 was used as the correlation between C_v and C_h . Table 2 below shows the results from the correlation between liquid limit values, C_v , and C_h .

Table 2 C_h from Liquid Limits				
Sample Number	Liquid Limit	C_v (undisturbed) (m ² /yr)	C_v (m ² /s)	C_h (m ² /sec)
1	83	1.2	3.8×10^{-8}	1.3×10^{-7}
2	76	1.5	4.8×10^{-8}	1.7×10^{-7}
4	54	4.0	1.3×10^{-7}	4.4×10^{-7}
5	54	4.0	1.3×10^{-7}	4.4×10^{-7}
6	82	1.2	3.8×10^{-8}	1.3×10^{-7}
7	84	1.2	3.8×10^{-8}	1.3×10^{-7}
8	27	18	5.7×10^{-7}	2.0×10^{-6}
Average =				4.9×10^{-7}



C_h values for individual samples were then used to estimate a range of representative C_h values for materials within the impoundment. The range selected was from $1.5 \times 10^{-7} \text{ m}^2/\text{sec}$ to $4.5 \times 10^{-7} \text{ m}^2/\text{sec}$. These "slow" and "fast" C_h values, along with a $U = 90\%$, were then used to calculate optimum wick drain spacing given a desired consolidation time of between 1 and 4 months.

Even though each of the correlations used in these analyses are approximate, they are as accurate as possible given the wide range of flow values likely present within the wastes. Based on results from previous remediation work and field investigations (SMI 2001) (Hecla 2001), waste materials within the impoundment are very heterogeneous and possess a wide range of grain size distributions, and therefore will have a significantly different C_v and C_h values (flow characteristics).

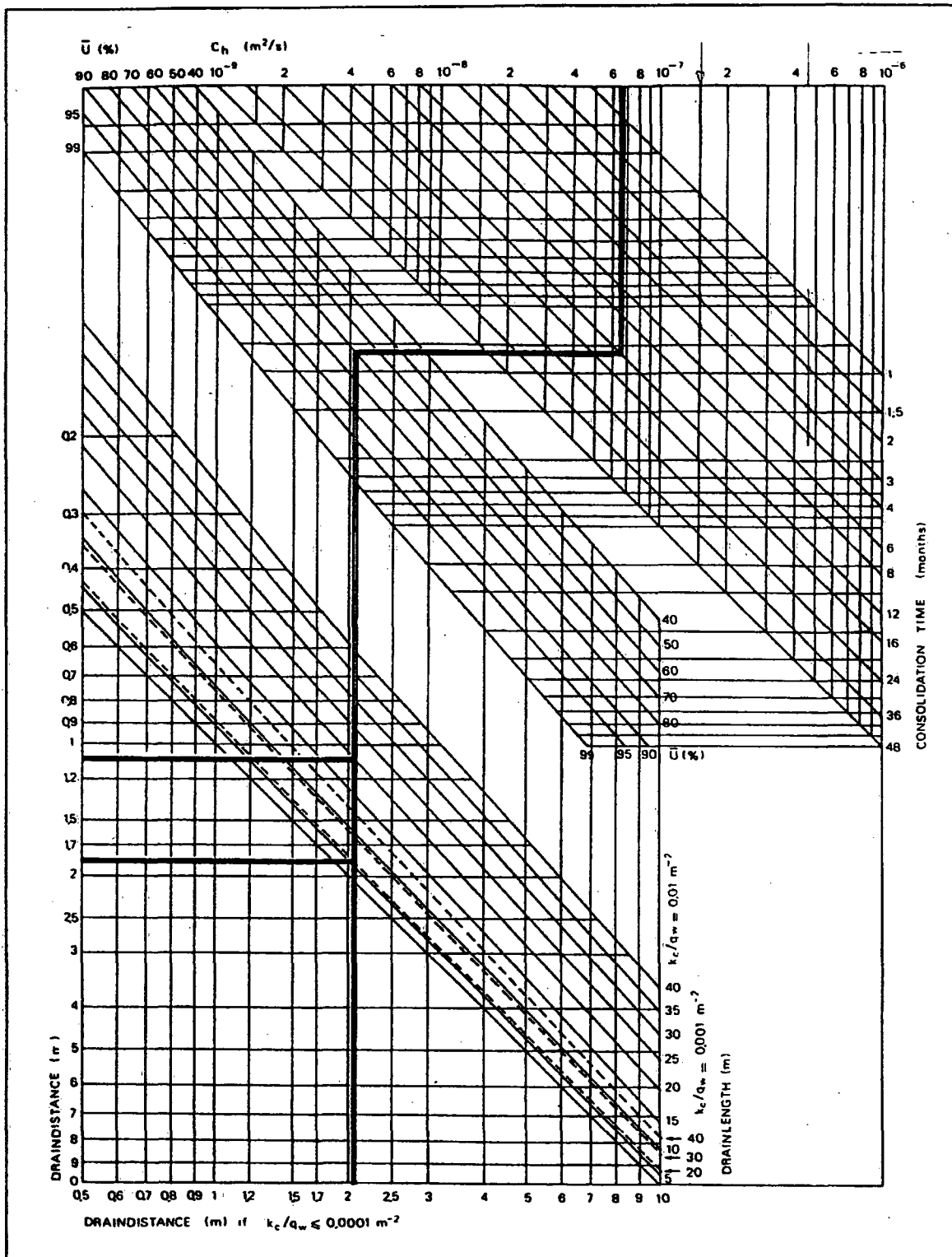
Calculated Drain Spacing

Using the estimated slow and fast C_h values of $1.5 \times 10^{-7} \text{ m}^2/\text{sec}$ and $4.5 \times 10^{-7} \text{ m}^2/\text{sec}$, optimum drain spacing was calculated based on NILEX's design guide (NILEX 2003). Table 3 below shows the results. A copy of NILEX's Wick Design Spacing Graph is attached on the following page.

Table 3 Time vs. Drain Spacing			
C_h (m^2/sec)	Time to Consolidation (months)	Drain Spacing (m)	Drain Spacing (ft)
1.5×10^{-7} (slow)	1	0.8	2.6
	2	1.05	3.4
	3	1.25	4.1
	4	1.35	4.4
4.5×10^{-7} (fast)	1	1.25	4.1
	2	1.65	5.4
	3	2.0	6.6
	4	2.2	7.2

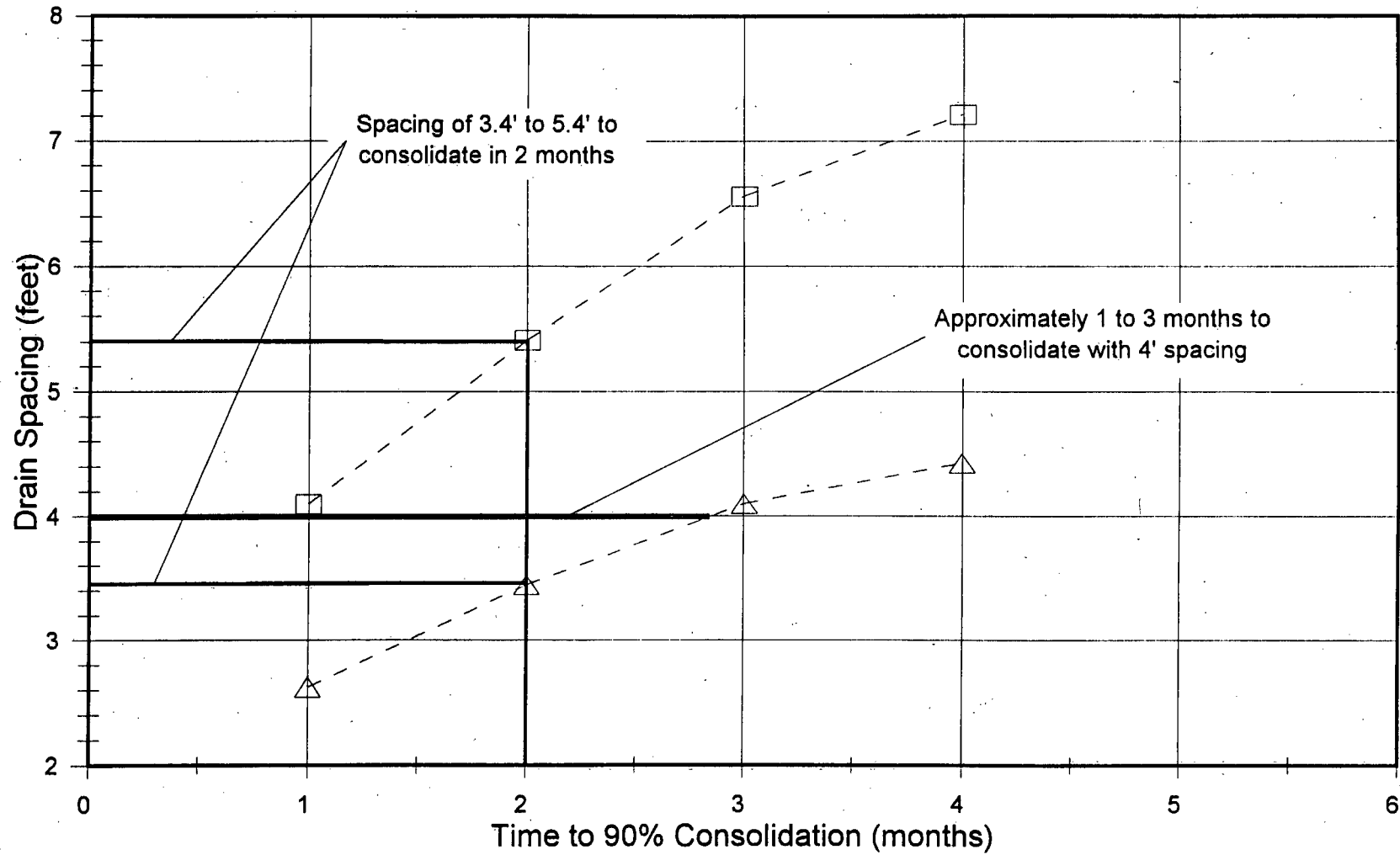
Average degree of consolidation $U = 90\%$

Data from Table 3 above is shown graphically on the second page following. Given the two C_h rates, the graph shows that drain spacing of between approximately 3.4 and 5.4 feet is required to successfully drain / consolidate the waste materials in 2 months.



- Wick Drain Spacing Graph

Drain Spacing vs. Time



— \triangle — $1.5 \times 10^{-7} m^2/sec$ — \square — $4.5 \times 10^{-7} m^2/sec$

Drain Cost Estimate

Table 4 below contains cost estimate data for various drain spacing designs. Data in this table is based on the latest cost information from NILEX.

Table 4 Drain Spacing vs. Cost							
Drain Spacing (ft)	Number of Drains Across ¹	Est. Drains/Acre	Lineal Feet/Acre ² (ft)	Total Lineal Feet (ft)	Estimated Cost/Foot (\$)	Total Cost (\$)	Total Cost w/ Mob. ³ (\$)
3	71	4,980	69,715	348,576	\$0.40	\$139,430	\$154,430
4	53	2,828	39,586	197,931	\$0.43	\$85,110	\$100,110
5	43	1,827	25,574	127,870	\$0.46	\$58,820	\$73,820
6	36	1,280	17,926	89,631	\$0.50	\$44,816	\$59,816
7	31	950	13,293	66,466	\$0.52	\$34,563	\$49,563
8	27	734	10,272	51,361	\$0.57	\$29,276	\$44,276
9	24	585	8,191	40,957	\$0.60	\$24,574	\$39,574
10	22	478	6,696	33,481	\$0.65	\$21,763	\$36,763

1 - Number of drains across one side of a 1 acre square assuming the given drain spacing.

2 - Based on estimated 14 foot depth for each drain.

3 - Mobilization = \$15,000

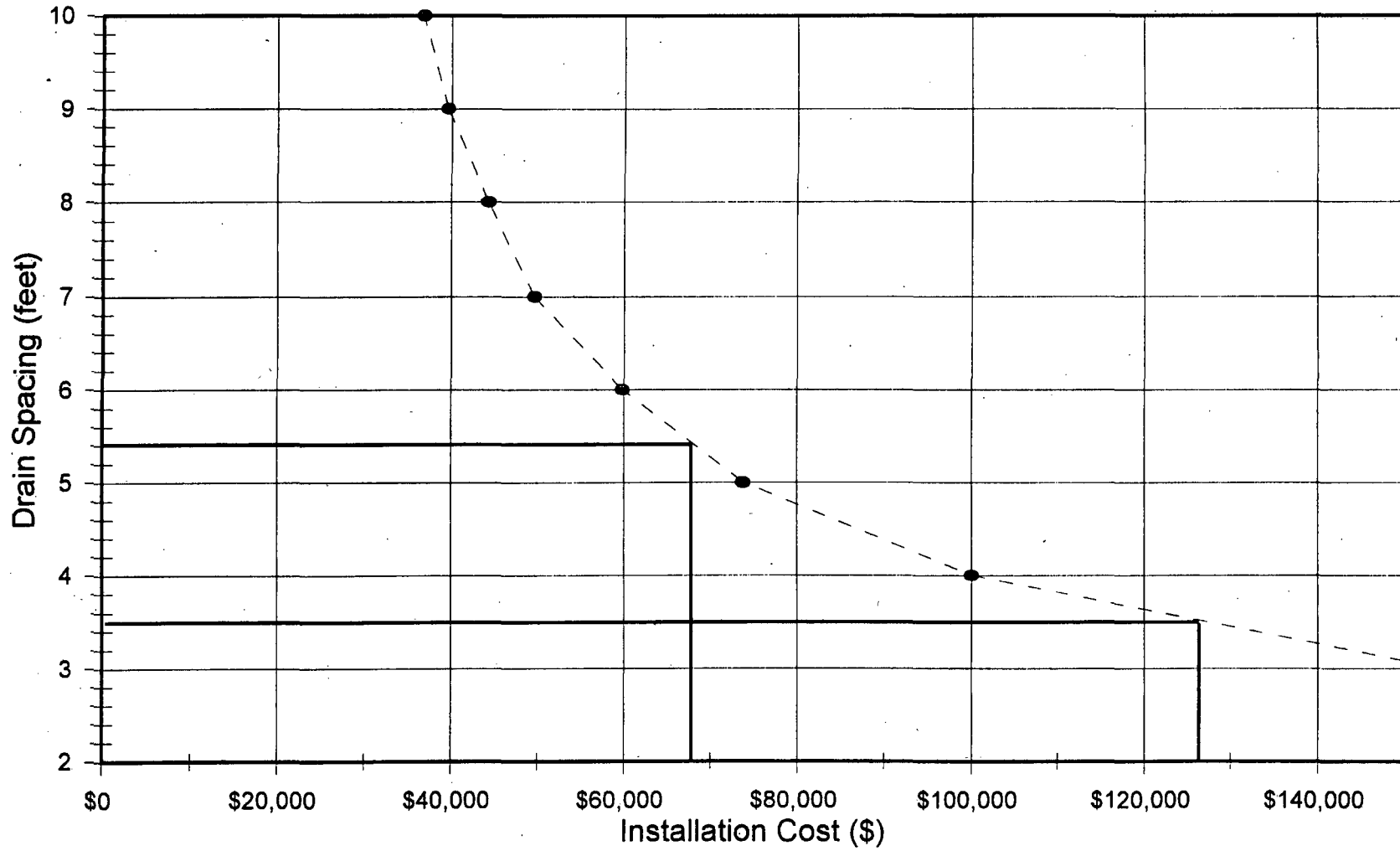
The graph on the following page plots data from Table 4 and shows estimated costs for any given drain spacing. As an example, the estimated installation cost for the required amount of drain material for a time of consolidation of 2 months (drain spacing of 3.4 to 5.4 feet) is between \$68,000 to \$120,000.

Summary

This analysis shows that based on laboratory testing results and estimated flow characteristics of the waste materials, a vertical wick drain spacing of approximately 3.4 to 5.4 feet is required in order to achieve 90% consolidation of the wastes in a period of approximately 2 months.

It is noted that preloading will increase the drains' effectiveness and will speed up the drainage / consolidation process. Based on Hecla's selected Final Closure Plan alternative, preloads will be added on top of the impoundment during embankment regrading.

Drain Spacing vs. Installation Cost



References

Holtz and Kovacs 1981. Holtz, R.D., and Kovacs, W.D., An Introduction to Geotechnical Engineering, Prentice-Hall, Inc. Englewood Cliffs, New Jersey, pp 402-404.

Bowles 1982. Bowles, J.E., Foundation Analysis and Design, McGraw-Hill, Inc., New York, pp 213-214.

Hecla 2001. Results of October 2001 Investigations; Apex Site Pond 2 - Soils Sampling and Analysis, Memorandum to Randall Breedon, USEPA, from Hecla Mining Company, December 3, 2001.

NILEX 2003. NILEX Corp., Vertical Wick Drains - -Technical Design Manual, Denver, CO.
nilex.com/pdf/install/wicktech.pdf

SMI 2001. Shepherd Miller Inc. Soil Sampling and Analysis Work Plan, prepared for Hecla Mining Company for the Apex Unit, August 30, 2001.

U.S. Navy 1971. "Soil Mechanics, Foundations, and Earth Structures," *NAVFAC Design Manual DM-7*, Washington, D.C.

Appendix E
Stability Analyses

Appendix E – Stability Analyses

Background

Slope stability analyses utilizing version 5.204 of the XSTABL computer program were conducted on two separate impoundment embankment cross-sections for Pond 2 at Hecla Mining Company's Apex Site. The two sections analyzed included:

- post excavation of a portion of the existing embankment (designated the Excavated Section)
- after completion of the final cover system (designated the Reclaimed Section)

Excavated Section geometry was based removing sufficient existing embankment material to expose the existing impoundment liner, leaving an approximate 1:1 (H:V) backslope. Reclaimed Section geometry was based on a final reconstructed embankment configuration of 3.5:1 (H:V), including all layers of the Final Cover System as designed for the Final Closure Plan.

Material Properties

Material locations (zones) and properties were based on information collected from previous field work (SMI 2001, Hecla 2001, MEI 2003), laboratory testing (MEI 2003), and correlations to standard material properties for materials similar to the impoundment embankment, temporary cover, liner (EPA 1996), and wastes. Table 1 below provides soil unit numbers, descriptions, weights, and strength parameters utilized in the analyses. Individual soil units are indicated on the attached stability analysis geometry sections. Eight different soil units were utilized in the Reclaimed Section.

Table 1 Material Types and Properties					
Soil Unit	Description	Moist Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Friction Angle (deg)
1	Rock Cover	130	135	0	40
2	Protection Layer	125	135	100	33
3	GCL ¹	90	100	290	25
4	Temporary Cover	115	125	50	38
5	Type IV Waste	65	68	200	20
6	Existing Embankment	120	130	50	38
7	Type I, II, and III Wastes	90	100	50	20
8	Reconstructed Embankment	120	130	200	30

Table Abbreviations: pcf – pounds per cubic foot
psf – pounds per square foot
deg – degrees
GCL – geocomposite clay liner

References: 1 – (Sharma 1994) - typical value for bentonite mat under free swell exposed to mild leachate
2 – (Bowles 1996) - conservative strength value for dense silty sand

Phreatic Surface

The fluid surface location (the phreatic surface) used in the stability analyses for both the Excavated and Reclaimed Sections are shown on the attached figures. The fluid surface was conservatively modeled to show saturated material conditions all the way to the outside edge of the Excavated Section. In general, the phreatic surface was located near the top of the Type IV Waste Material layer (at the bottom of the Temporary Cover Material), angled down towards the top of the existing embankment, turned sharply downward along the outer face of the remaining existing embankment, then downward away from the impoundment into the native soil layer.

Results - Excavated Section

The Excavated Section was analyzed utilizing a circular failure surface search routine with factors of safety calculated by the simplified Bishop method. One hundred (100) failure surfaces were analyzed and are shown on an attached figure. An additional figure shows the 10 most critical failure surfaces. The lowest factor of safety calculated for the Excavated Section was 1.6. The factor of safety range for the 10 most critical failure surfaces was between 1.6 and 2.0.

Results - Reclaimed Section

A circular failure surface search routine using the simplified Bishop method was also used on the Reclaimed Section. One hundred (100) failure surfaces were analyzed (shown on an attached figure), with the 10 most critical failure surfaces shown separately. The lowest factor of safety calculated for the Reclaimed Section was 4.1, and the factor of safety range for the 10 most critical surfaces was between 4.1 and 4.8.

Due to the bilinear geometry of the surface between the excavated slope and the reconstructed embankment, and the potential for slip-plane development in the GCL layer, a block failure search routine was also utilized to analyze the Reclaimed Section. Figures showing section geometry, the 100 failure surfaces analyzed, and the 10 most critical failure surfaces are attached. The lowest factor of safety calculated for the Reclaimed Section utilizing this block failure search routine was 4.5, and the factor of safety range for the 10 most critical failure surfaces was 4.5 to 4.9.

REFERENCES

- Bowles 1996. Bowles, Joseph E. "Foundation Analysis and Design." The McGraw-Hill Companies, Inc., New York.
- EPA 1996. Daniel, D.E. and Scranton, H.B. "Report of 1995 Workshop on Geosynthetic Clay Liners", National Risk Management Research Laboratory, Office of Research and Development, June 1996, EPA/600/R-96/149.

Hecla 2001. Results of October 2001 Investigation; Apex Site Pond 2 – Soils Sampling and Analysis, Memorandum to Randall Breedon, USEPA, from Hecla Mining Company, December 3, 2001.

MEI 2003. Monster Engineering Inc. Potential Borrow Source Materials Investigation; Apex Site – Hecla Mining Company, Technical Memorandum prepared for Chris Gypton, Hecla Mining Company, February 3, 2003.

Sharma 1994. Sharma, Hari D. and Lewis, S.P. "Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation." John Wiley & Sons, Inc, New York.

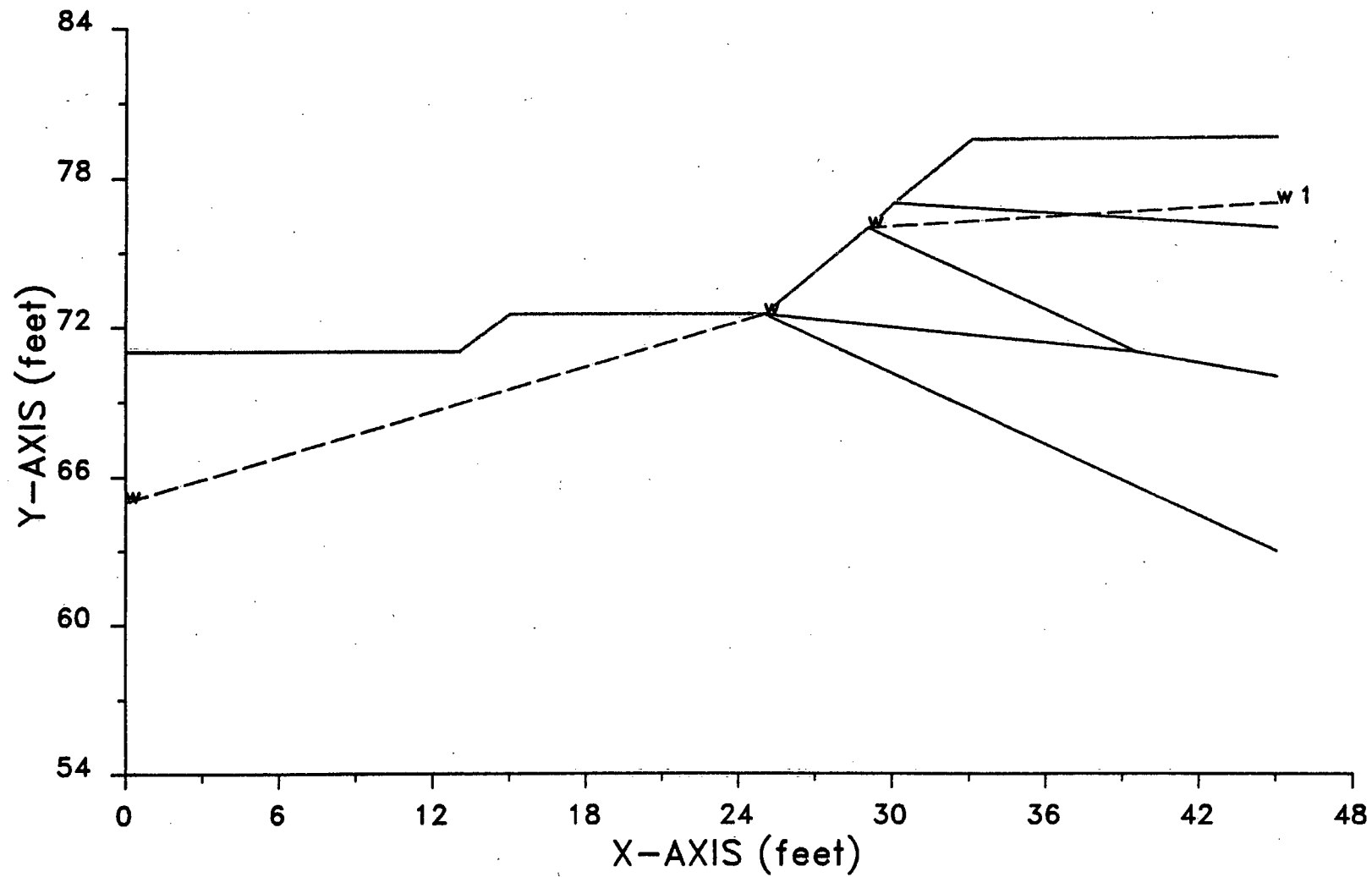
SMI 2001. Shephre Miller Inc. Soil Sampling and Analysis Work Plan, prepared for Hecla Mining Company for the Apex Unit, August 30, 2001.

Appendix E – Stability Analyses
Section Plots and Analyses Outputs

XSTABL Output
Excavated Section
Circular Failure Surfaces

EXC 8-15-03 20:00

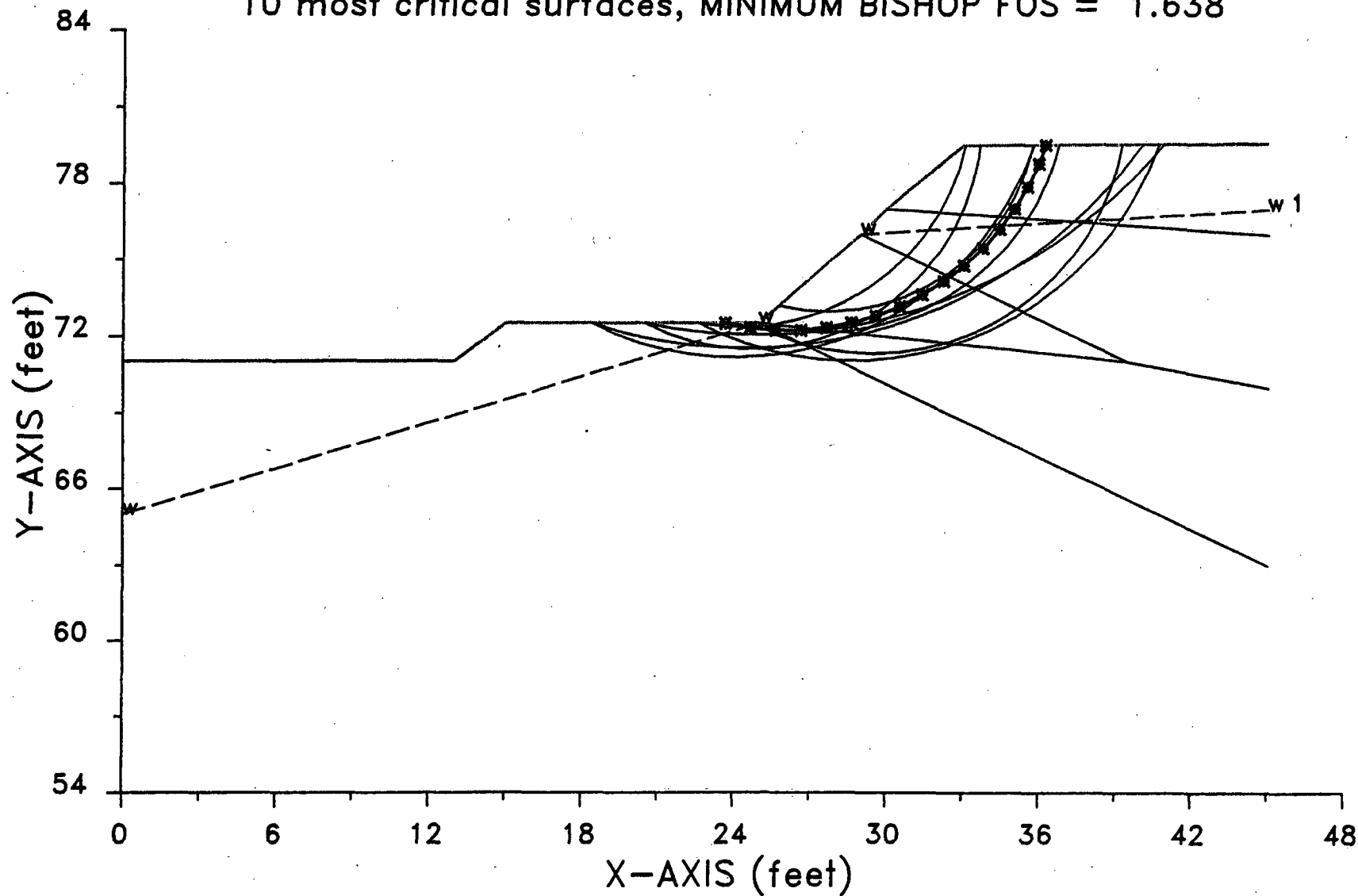
APEX POND 2 EXCAVATED CROSS SECTION



EXC 8-15-03 20:00

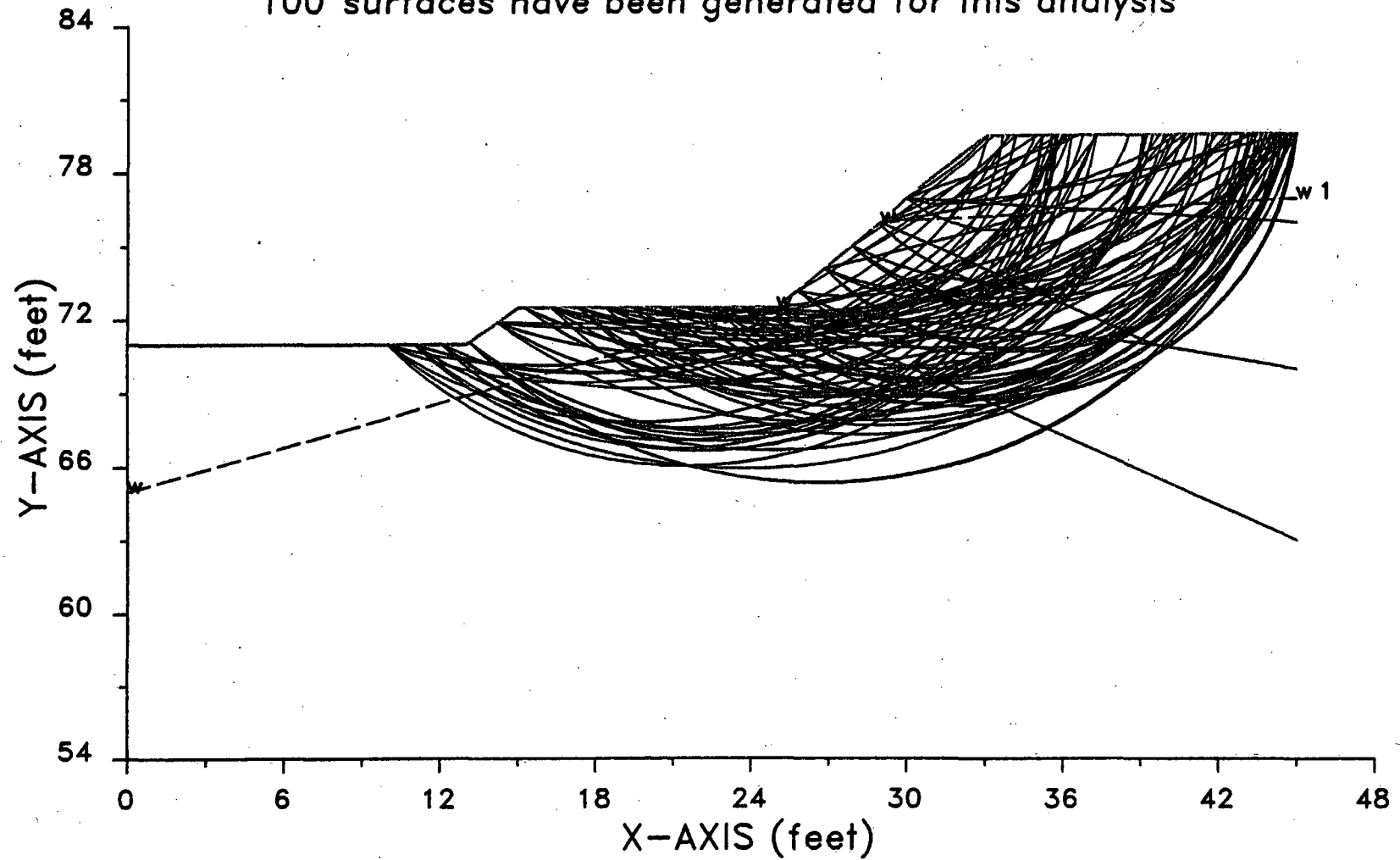
APEX POND 2 EXCAVATED CROSS SECTION

10 most critical surfaces, MINIMUM BISHOP FOS = 1.638



EXC 8-15-03 20:00

APEX POND 2 EXCAVATED CROSS SECTION
100 surfaces have been generated for this analysis



0110007

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*****
*               X S T A B L               *
*               Slope Stability Analysis   *
*               using the                   *
*               Method of Slices           *
*               Copyright (C) 1992 - 99    *
*               Interactive Software Designs, Inc. *
*               Moscow, ID 83843, U.S.A.   *
*               All Rights Reserved        *
*               Ver. 5.204                  96 - 1773 *
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Problem Description : APEX POND 2 EXCAVATED CROSS SECTION

 SEGMENT BOUNDARY COORDINATES

7 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	71.0	13.0	71.0	6
2	13.0	71.0	15.0	72.5	6
3	15.0	72.5	25.0	72.5	6
4	25.0	72.5	29.0	76.0	6
5	29.0	76.0	30.0	77.0	5
6	30.0	77.0	33.0	79.5	4
7	33.0	79.5	45.0	79.6	4

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	30.0	77.0	45.0	76.0	5
2	29.0	76.0	39.5	71.0	6
3	25.0	72.5	39.5	71.0	7
4	39.5	71.0	45.0	70.0	7
5	25.0	72.5	45.0	63.0	6

 ISOTROPIC Soil Parameters

7 Soil unit(s) specified

Soil Unit No.	Unit Moist (pcf)	Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pressure Constant (psf)	Water Surface No.
1	130.0	135.0	.0	40.00	.000	.0	1
2	125.0	135.0	100.0	33.00	.000	.0	1
3	90.0	100.0	290.0	25.00	.000	.0	1
4	115.0	125.0	50.0	38.00	.000	.0	1
5	65.0	68.0	200.0	20.00	.000	.0	1
6	120.0	130.0	50.0	38.00	.000	.0	1
7	90.0	100.0	50.0	20.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 4 coordinate points

PHREATIC SURFACE,

Point No.	x-water (ft)	y-water (ft)
1	.00	65.00
2	25.00	72.50
3	29.00	76.00
4	45.00	77.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

100 trial surfaces will be generated and analyzed.

5 Surfaces initiate from each of 20 points equally spaced along the ground surface between x = 10.0 ft and x = 30.0 ft

Each surface terminates between x = 33.0 ft and x = 45.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 65.0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter. In such
cases, this effect can only be eliminated by reducing the "c" value.

USER SELECTED option for unrestricted values of strength

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 17 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	23.68	72.50
2	24.67	72.32
3	25.66	72.23
4	26.66	72.23
5	27.66	72.33
6	28.64	72.52
7	29.60	72.80
8	30.53	73.17
9	31.42	73.63

10	32.26	74.16
11	33.05	74.78
12	33.78	75.46
13	34.44	76.21
14	35.03	77.02
15	35.54	77.88
16	35.97	78.78
17	36.24	79.53

**** Simplified BISHOP FOS = 1.638 ****

The following is a summary of the TEN most critical surfaces

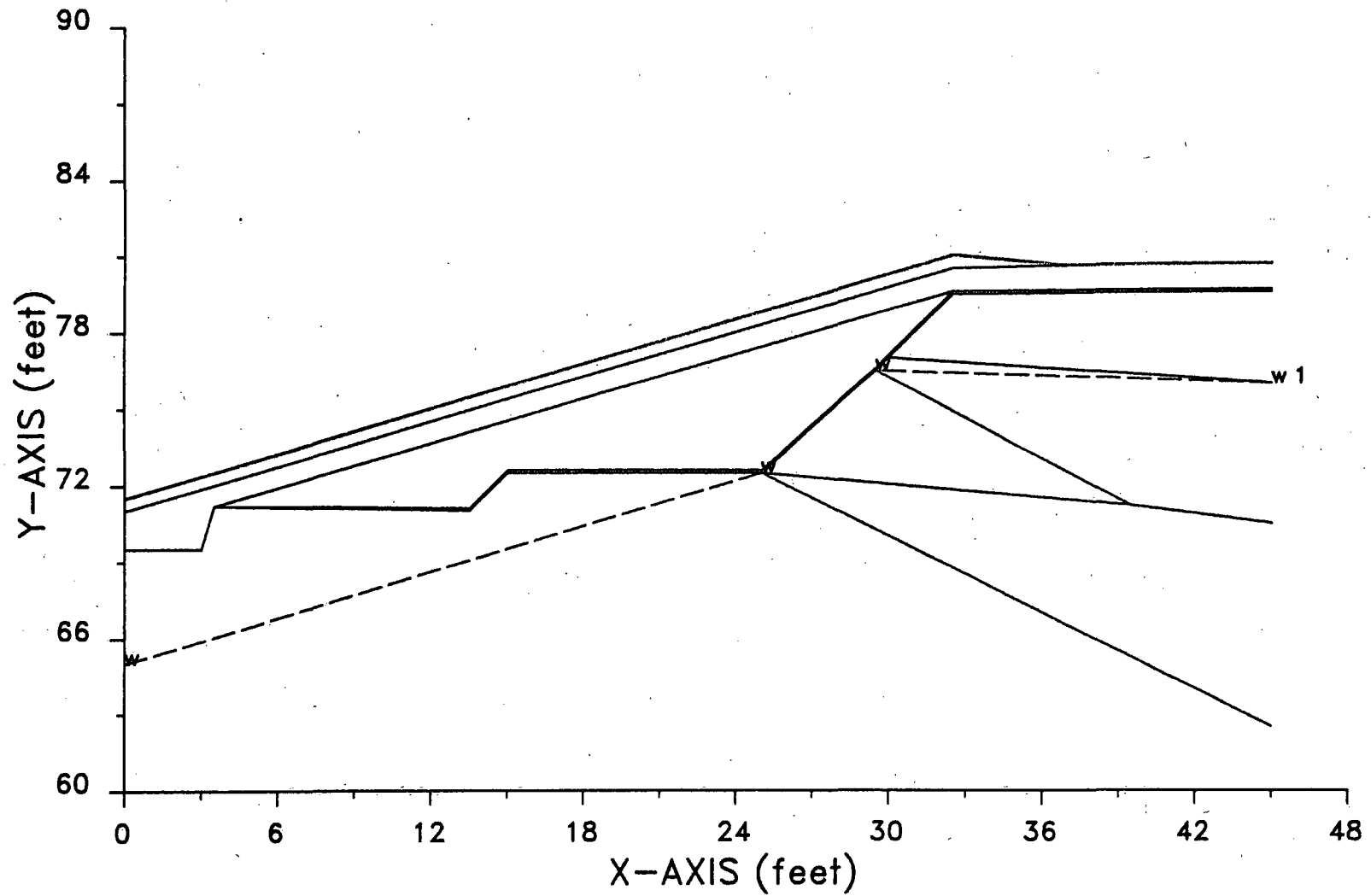
Problem Description : APEX POND 2 EXCAVATED CROSS SECTION

	FOS (BISHOP)	Circle Center x-coord (ft)	y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.638	26.12	82.89	10.67	23.68	36.24	2.917E+04
2.	1.664	27.36	81.83	9.69	24.74	36.76	2.849E+04
3.	1.834	29.46	81.23	9.92	24.74	39.23	3.851E+04
4.	1.841	24.70	80.50	9.02	20.53	33.65	2.312E+04
5.	1.851	27.70	81.17	8.21	25.79	35.73	1.993E+04
6.	1.871	28.61	83.84	12.82	22.63	40.69	6.056E+04
7.	1.890	24.26	81.38	9.02	22.63	33.09	1.489E+04
8.	1.912	24.05	83.56	12.41	18.42	35.77	4.482E+04
9.	1.970	24.46	90.67	19.14	18.42	40.04	8.756E+04
10.	2.009	24.85	92.90	20.86	20.53	40.88	9.040E+04

* * * END OF FILE * * *

XSTABL Output
Reclaimed Section
Circular Failure Surfaces

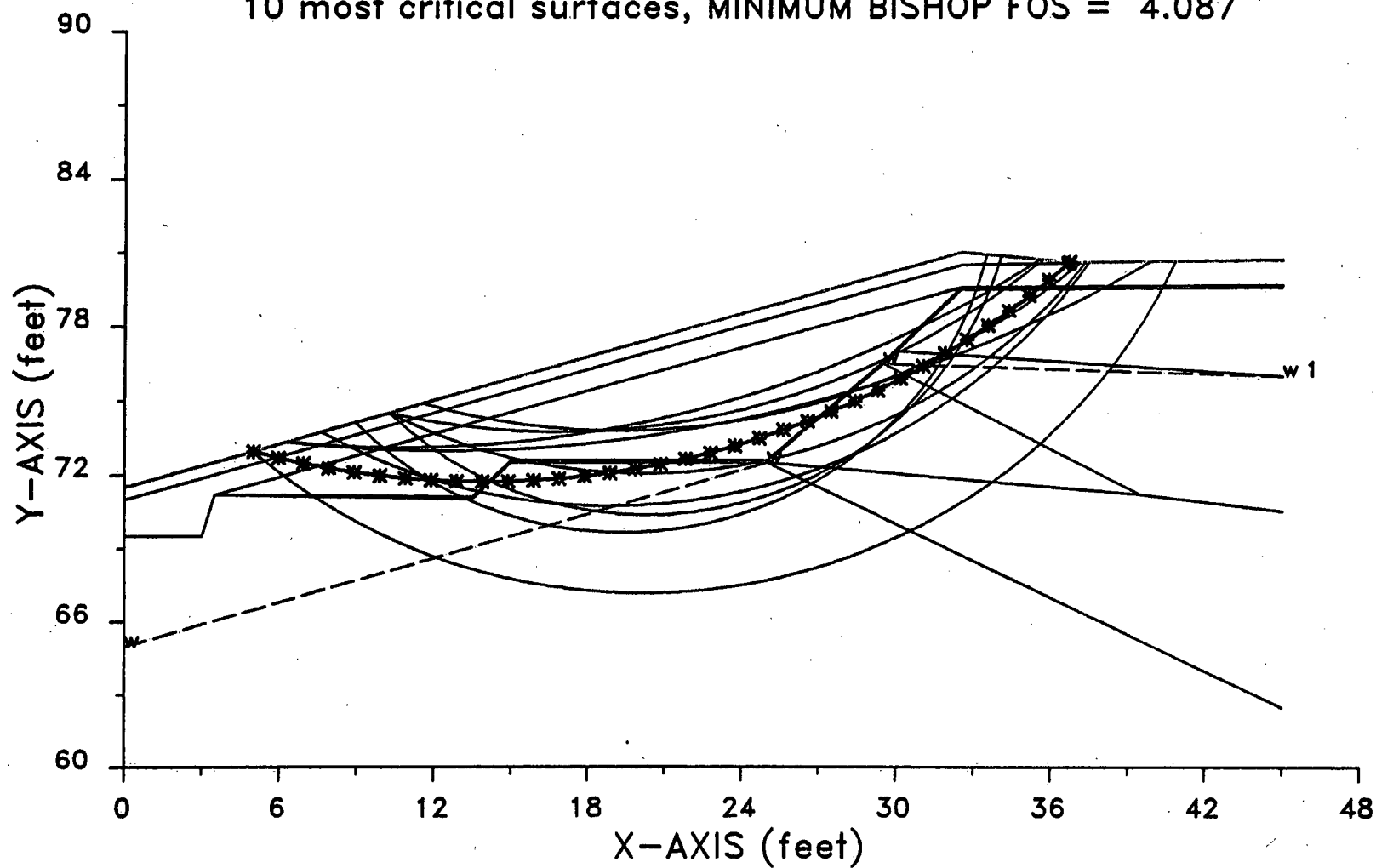
APEX POND 2 RECLAIMED CROSS SECTION



w 1

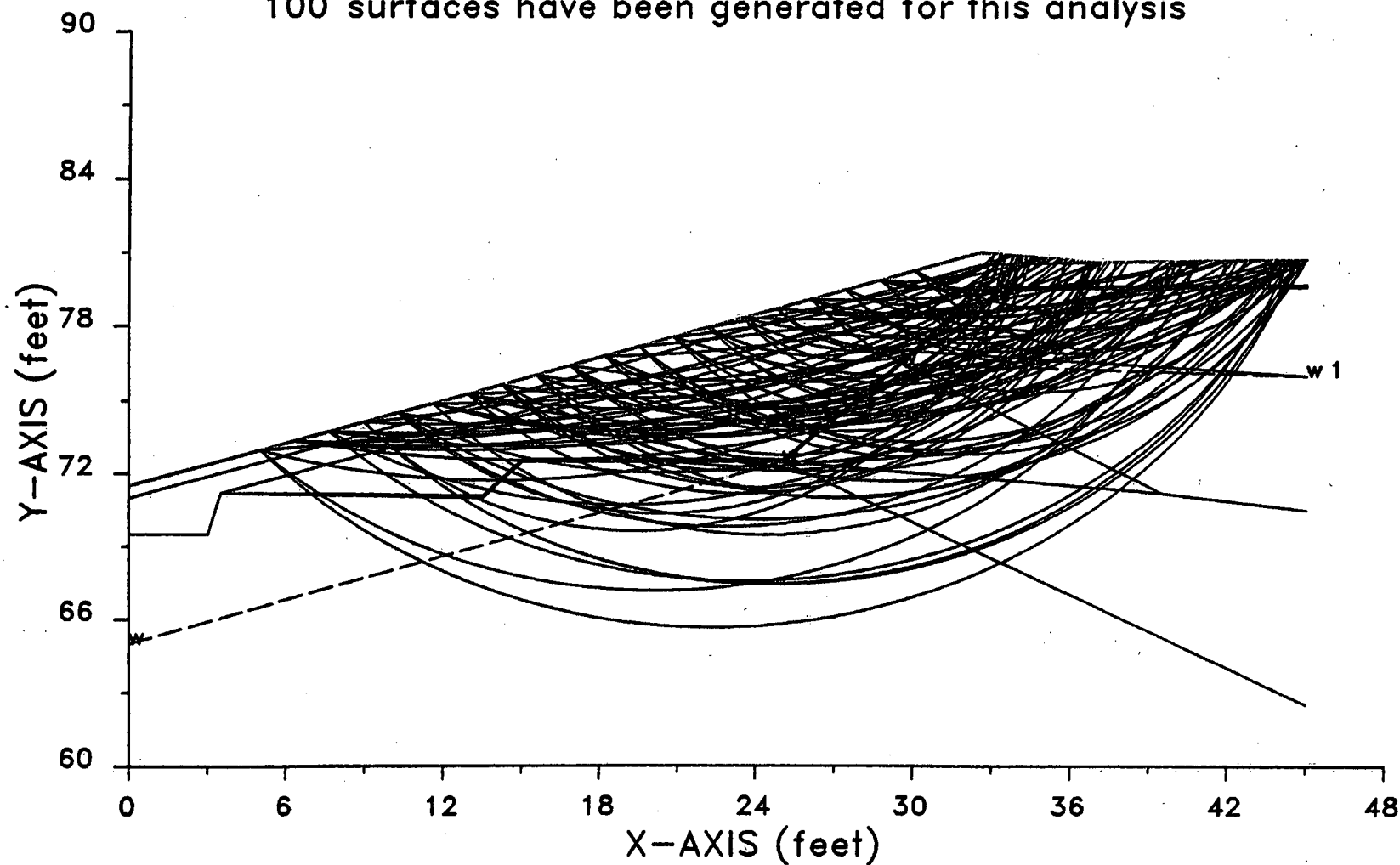
9400146

APEX POND 2 RECLAIMED CROSS SECTION
10 most critical surfaces, MINIMUM BISHOP FOS = 4.087



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APEX POND 2 RECLAIMED CROSS SECTION
100 surfaces have been generated for this analysis



AP00118

```

*****
*               X S T A B L               *
*               Slope Stability Analysis    *
*               using the                   *
*               Method of Slices            *
*               Copyright (C) 1992 - 99     *
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*               Moscow, ID 83843, U.S.A.    *
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*               Ver. 5.204                   96 - 1773 *
*****

```

Problem Description : APEX POND 2 RECLAIMED CROSS SECTION

 SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	71.5	32.5	81.0	1
2	32.5	81.0	37.0	80.6	1
3	37.0	80.6	45.0	80.7	2

24 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	71.0	32.5	80.5	2
2	32.5	80.5	37.0	80.6	2
3	.0	69.5	3.0	69.5	6
4	3.0	69.5	3.5	71.2	6
5	3.5	71.2	32.5	79.6	8
6	32.5	79.6	45.0	79.7	3
7	3.5	71.2	13.5	71.1	3
8	13.5	71.1	15.0	72.6	3
9	15.0	72.6	25.0	72.6	3
10	25.0	72.6	29.5	76.6	3
11	29.5	76.6	30.0	77.1	3
12	30.0	77.1	32.5	79.6	3
13	3.5	71.2	13.5	71.0	6
14	13.5	71.0	15.0	72.5	6

15	15.0	72.5	25.0	72.5	6
16	25.0	72.5	29.5	76.5	6
17	29.5	76.5	30.0	77.0	5
18	30.0	77.0	32.5	79.5	4
19	32.5	79.5	45.0	79.6	4
20	30.0	77.0	45.0	76.0	5
21	29.5	76.5	39.5	71.2	6
22	39.5	71.2	45.0	70.5	7
23	25.0	72.5	39.5	71.2	7
24	25.0	72.5	45.0	62.5	6

ISOTROPIC Soil Parameters

8 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	130.0	135.0	.0	40.00	.000	.0	1
2	125.0	135.0	100.0	33.00	.000	.0	1
3	90.0	100.0	290.0	25.00	.000	.0	1
4	115.0	125.0	50.0	38.00	.000	.0	1
5	65.0	68.0	200.0	20.00	.000	.0	1
6	120.0	130.0	50.0	38.00	.000	.0	1
7	90.0	100.0	50.0	20.00	.000	.0	1
8	120.0	130.0	200.0	30.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 4 coordinate points

PHREATIC SURFACE,

Point No.	x-water (ft)	y-water (ft)
1	.00	65.00
2	25.00	72.50
3	29.50	76.50
4	45.00	76.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

100 trial surfaces will be generated and analyzed.

5 Surfaces initiate from each of 20 points equally spaced
along the ground surface between $x = 5.0$ ft
and $x = 30.0$ ft

Each surface terminates between $x = 33.0$ ft
and $x = 45.0$ ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is $y = 65.0$ ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)

Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter. In such
cases, this effect can only be eliminated by reducing the "c" value.

USER SELECTED option for unrestricted values of strength

** Factor of safety calculation for surface # 86 **
** failed to converge within FIFTY iterations **
**
** The last calculated value of the FOS was 23.2102 **
** This will be ignored for final summary of results **

Circular surface (FOS= 23.2102) is defined by: xcenter = 32.98
ycenter = 84.49 Init. Pt. = 27.37 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    89      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was 31.3215     **
**      This will be ignored for final summary of results   **
*****
```

Circular surface (FOS= 31.3215) is defined by: xcenter = 35.05
ycenter = 96.14 Init. Pt. = 27.37 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    90      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was 30.5756     **
**      This will be ignored for final summary of results   **
*****
```

Circular surface (FOS= 30.5756) is defined by: xcenter = 34.29
ycenter = 86.16 Init. Pt. = 27.37 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    91      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was 28.1857     **
**      This will be ignored for final summary of results   **
*****
```

Circular surface (FOS= 28.1857) is defined by: xcenter = 32.95
ycenter = 85.04 Init. Pt. = 28.68 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    92      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was 92.1059     **
**      This will be ignored for final summary of results   **
*****
```

Circular surface (FOS= 92.1059) is defined by: xcenter = 35.80
ycenter = 86.91 Init. Pt. = 28.68 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    93      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was 39.7618     **
**      This will be ignored for final summary of results    **
*****
```

Circular surface (FOS= 39.7618) is defined by: xcenter = 33.10
ycenter = 102.25 Init. Pt. = 28.68 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    97      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was-215.3285     **
**      This will be ignored for final summary of results    **
*****
```

Circular surface (FOS=*****) is defined by: xcenter = 37.24
ycenter = 86.85 Init. Pt. = 30.00 Seg. Length = 1.00

```
*****
**      Factor of safety calculation for surface #    98      **
**      failed to converge within FIFTY iterations          **
**                                                         **
**      The last calculated value of the FOS was-331.1221     **
**      This will be ignored for final summary of results    **
*****
```

Circular surface (FOS=*****) is defined by: xcenter = 36.43
ycenter = 91.65 Init. Pt. = 30.00 Seg. Length = 1.00

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 36 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	5.00	72.96
2	5.97	72.71
3	6.94	72.48
4	7.92	72.28
5	8.91	72.11
6	9.90	71.98
7	10.89	71.87
8	11.89	71.79
9	12.89	71.74
10	13.89	71.72
11	14.89	71.73
12	15.89	71.77
13	16.88	71.85
14	17.88	71.95
15	18.87	72.08
16	19.86	72.24
17	20.84	72.43
18	21.81	72.65
19	22.78	72.90
20	23.74	73.17
21	24.70	73.48
22	25.64	73.81
23	26.57	74.18
24	27.49	74.57
25	28.40	74.98
26	29.29	75.43
27	30.18	75.90
28	31.04	76.40
29	31.90	76.92
30	32.73	77.47
31	33.55	78.04
32	34.35	78.64
33	35.14	79.26
34	35.90	79.91
35	36.65	80.58
36	36.70	80.63

**** Simplified BISHOP FOS = 4.087 ****

```

*****
**
** Out of the 100 surfaces generated and analyzed by XSTABL, **
** 8 surfaces were found to have MISLEADING FOS values. **
**
*****

```

The following is a summary of the TEN most critical surfaces

Problem Description : APEX POND 2 RECLAIMED CROSS SECTION

	FOS (BISHOP)	Circle Center x-coord (ft)	y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	4.087	14.01	105.08	33.36	5.00	36.70	4.483E+05
2.	4.284	18.85	93.18	22.46	7.63	37.45	3.474E+05
3.	4.510	20.20	93.44	21.38	10.26	37.30	2.731E+05
4.	4.580	16.86	102.46	28.72	10.26	35.63	2.663E+05
5.	4.636	10.82	116.99	43.87	6.32	35.52	4.385E+05
6.	4.680	12.50	125.55	52.57	6.32	39.82	6.436E+05
7.	4.695	19.21	100.64	26.86	11.58	37.09	2.626E+05
8.	4.727	20.12	89.77	22.61	5.00	40.81	5.505E+05
9.	4.752	19.39	84.06	14.43	8.95	33.47	2.231E+05
10.	4.757	20.30	84.60	14.24	10.26	34.04	2.013E+05

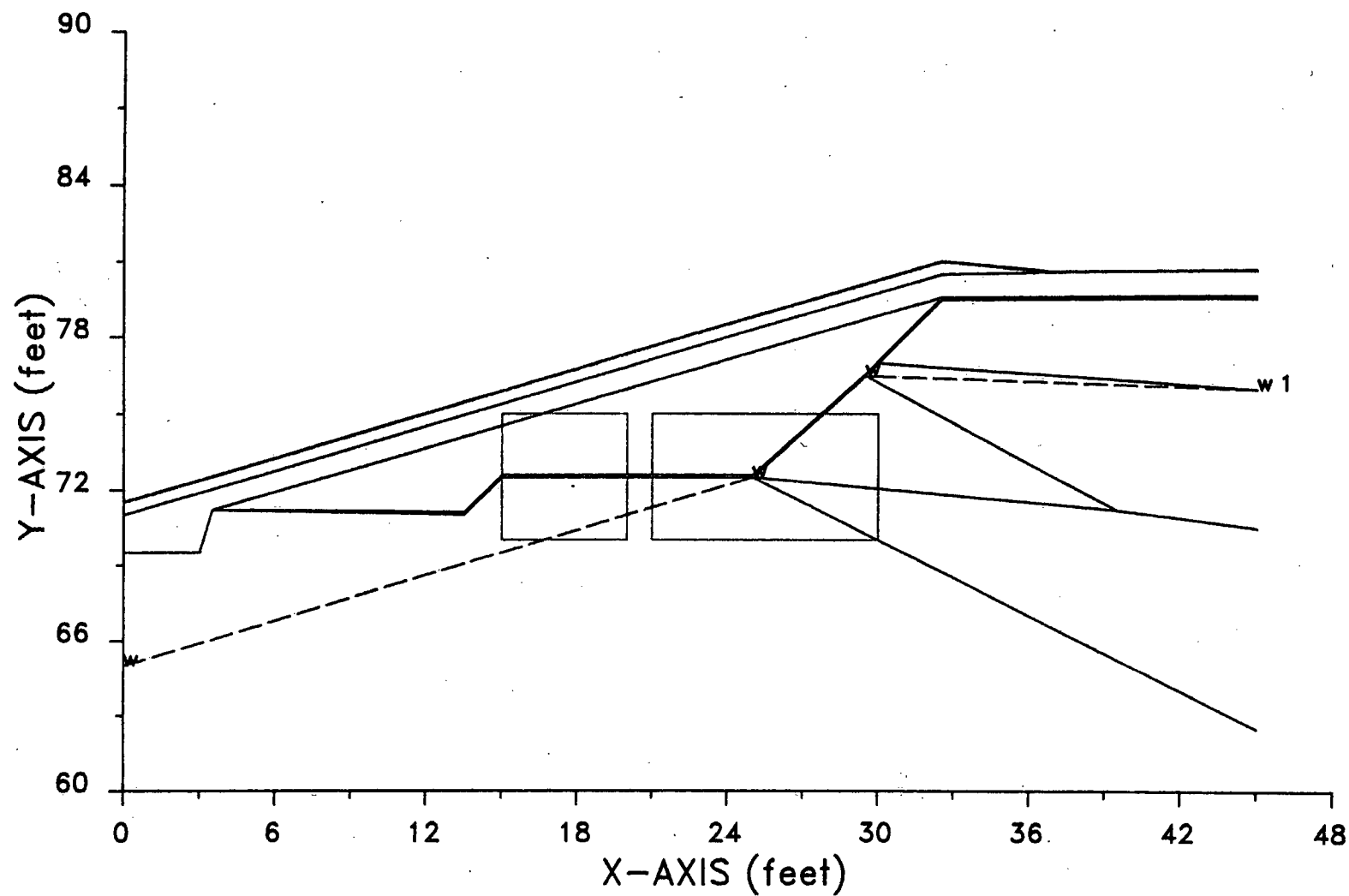
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XSTABL Output

Reclaimed Section

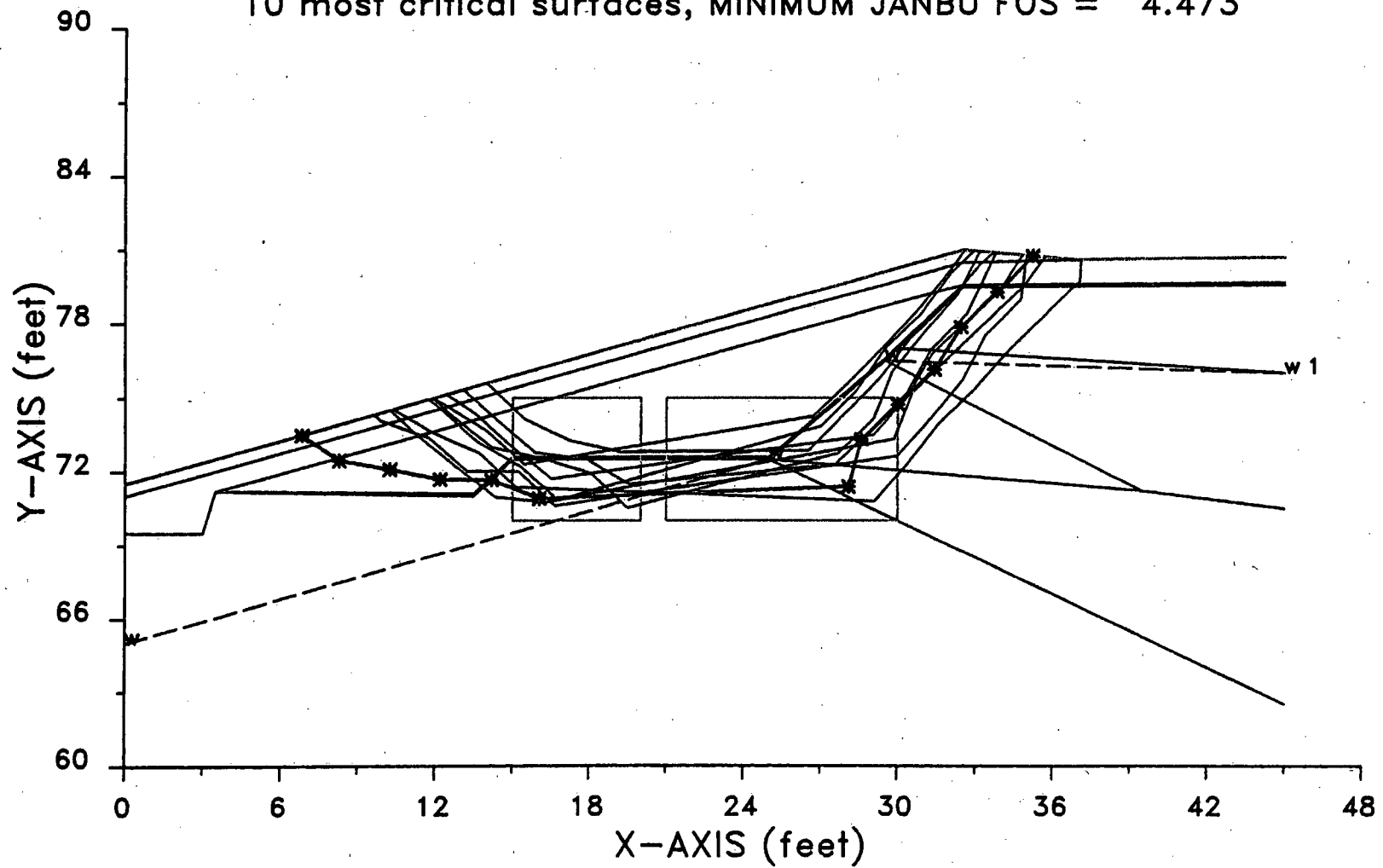
Block Failure Surfaces

APEX POND 2 RECLAIMED CROSS SECTION



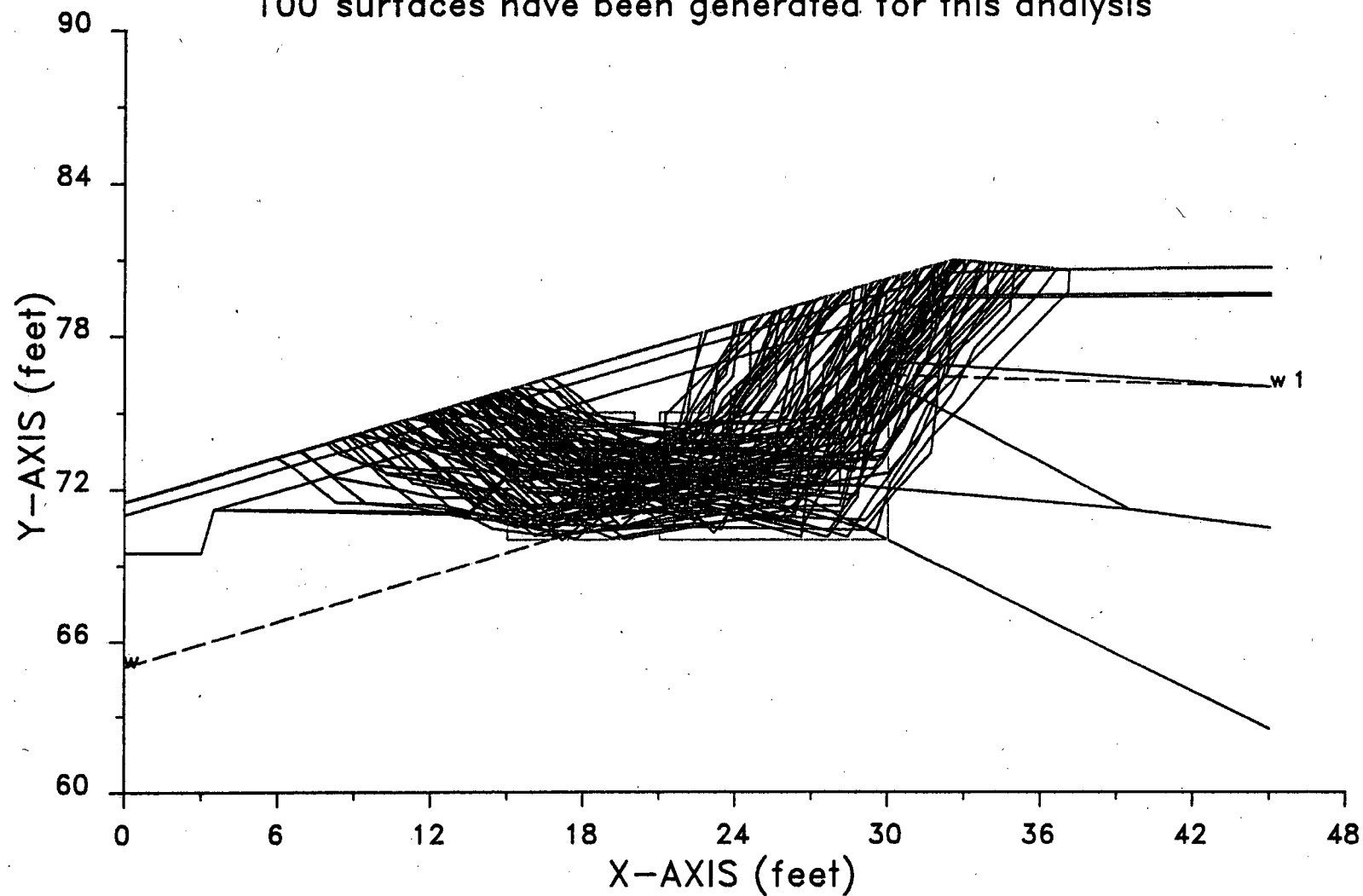
APEX POND 2 RECLAIMED CROSS SECTION

10 most critical surfaces, MINIMUM JANBU FOS = 4.473



APEX POND 2 RECLAIMED CROSS SECTION

100 surfaces have been generated for this analysis



```

*****
*               X S T A B L               *
*               *                           *
*      Slope Stability Analysis             *
*      using the                           *
*      Method of Slices                    *
*               *                           *
*      Copyright (C) 1992 - 99             *
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*               *                           *
*      Ver. 5.204                          96 - 1773 *
*****

```

Problem Description : APEX POND 2 RECLAIMED CROSS SECTION

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	71.5	32.5	81.0	1
2	32.5	81.0	37.0	80.6	1
3	37.0	80.6	45.0	80.7	2

24 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	71.0	32.5	80.5	2
2	32.5	80.5	37.0	80.6	2
3	.0	69.5	3.0	69.5	6
4	3.0	69.5	3.5	71.2	6
5	3.5	71.2	32.5	79.6	8
6	32.5	79.6	45.0	79.7	3
7	3.5	71.2	13.5	71.1	3
8	13.5	71.1	15.0	72.6	3
9	15.0	72.6	25.0	72.6	3
10	25.0	72.6	29.5	76.6	3
11	29.5	76.6	30.0	77.1	3
12	30.0	77.1	32.5	79.6	3
13	3.5	71.2	13.5	71.0	6
14	13.5	71.0	15.0	72.5	6
15	15.0	72.5	25.0	72.5	6
16	25.0	72.5	29.5	76.5	6
17	29.5	76.5	30.0	77.0	5
18	30.0	77.0	32.5	79.5	4
19	32.5	79.5	45.0	79.6	4
20	30.0	77.0	45.0	76.0	5
21	29.5	76.5	39.5	71.2	6
22	39.5	71.2	45.0	70.5	7
23	25.0	72.5	39.5	71.2	7

24 25.0 72.5 45.0 62.5 6

ISOTROPIC Soil Parameters

8 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	130.0	135.0	.0	40.00	.000	.0	1
2	125.0	135.0	100.0	33.00	.000	.0	1
3	90.0	100.0	290.0	25.00	.000	.0	1
4	115.0	125.0	50.0	38.00	.000	.0	1
5	65.0	68.0	200.0	20.00	.000	.0	1
6	120.0	130.0	50.0	38.00	.000	.0	1
7	90.0	100.0	50.0	20.00	.000	.0	1
8	120.0	130.0	200.0	30.00	.000	.0	1

1 Water surface(s) have been specified
Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 4 coordinate points

PHREATIC SURFACE,

Point No.	x-water (ft)	y-water (ft)
1	.00	65.00
2	25.00	72.50
3	29.50	76.50
4	45.00	76.00

A critical failure surface searching method, using a random technique for generating sliding BLOCK surfaces, has been specified.

100 trial surfaces will be generated and analyzed.

2 boxes specified for generation of central block base

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

Length of line segments for active and passive portions of sliding block is 2.0 ft

Box no.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Width (ft)
1	15.0	72.5	20.0	72.5	5.0
2	21.0	72.5	30.0	72.5	5.0

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED JANBU METHOD * * * * *

The 10 most critical of all the failure surfaces examined are displayed below - the most critical first

Failure surface No. 1 specified by 14 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	6.84	73.50
2	8.28	72.47
3	10.25	72.11
4	12.20	71.69
5	14.20	71.66
6	16.05	70.90
7	28.10	71.38
8	28.60	73.32
9	30.01	74.74
10	31.42	76.15
11	32.44	77.87
12	33.84	79.31
13	35.22	80.76
14	35.22	80.76

** Corrected JANBU FOS = 4.473 ** (Fo factor = 1.081)

Failure surface No. 2 specified by 11 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	10.27	74.50
2	11.26	73.52
3	12.79	72.23
4	14.34	70.97
5	16.33	70.76
6	29.87	73.33
7	30.57	75.21
8	31.96	76.64
9	33.37	78.06
10	34.79	79.47
11	35.68	80.72

** Corrected JANBU FOS = 4.619 ** (Fo factor = 1.076)

Failure surface No. 3 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	13.10	75.33
2	14.40	74.11
3	15.89	72.78
4	17.87	72.52
5	19.59	71.48
6	27.59	72.31
7	28.99	73.74
8	30.35	75.21
9	31.29	76.97
10	32.67	78.43
11	33.48	80.25
12	33.77	80.89

** Corrected JANBU FOS = 4.626 ** (Fo factor = 1.088)

Failure surface No. 4 specified by 10 coordinate points

Point	x-surf	y-surf
-------	--------	--------

No.	(ft)	(ft)
1	12.44	75.14
2	13.55	74.38
3	15.00	73.00
4	16.52	71.71
5	29.07	73.51
6	30.36	75.04
7	31.32	76.79
8	32.74	78.21
9	34.10	79.67
10	34.80	80.80

** Corrected JANBU FOS = 4.729 ** (Fo factor = 1.081)

Failure surface No. 5 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	10.38	74.53
2	11.91	73.60
3	13.72	72.75
4	15.15	71.35
5	29.11	70.79
6	30.39	72.33
7	31.57	73.95
8	32.98	75.37
9	34.26	76.91
10	35.66	78.33
11	37.05	79.77
12	37.09	80.60

** Corrected JANBU FOS = 4.764 ** (Fo factor = 1.086)

Failure surface No. 6 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	14.01	75.60
2	14.05	75.56
3	15.47	74.15
4	17.27	73.27
5	19.21	72.81
6	26.54	72.87
7	27.91	74.33
8	29.28	75.79
9	30.47	77.40
10	31.86	78.83
11	33.13	80.38
12	33.65	80.90

** Corrected JANBU FOS = 4.782 ** (Fo factor = 1.086)

Failure surface No. 7 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	9.63	74.31
2	9.89	74.08
3	11.76	73.39

4	13.24	72.04
5	15.24	72.02
6	16.67	70.62
7	29.98	72.64
8	31.27	74.17
9	32.51	75.74
10	33.38	77.54
11	34.75	78.99
12	34.96	80.78

** Corrected JANBU FOS = 4.798 ** (Fo factor = 1.082)

Failure surface No. 8 specified by 12 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	11.91	74.98
2	12.68	74.26
3	14.22	72.99
4	16.17	72.54
5	18.07	71.93
6	19.50	70.53
7	27.69	72.75
8	29.08	74.19
9	29.77	76.07
10	31.00	77.64
11	32.28	79.18
12	33.14	80.94

** Corrected JANBU FOS = 4.842 ** (Fo factor = 1.086)

Failure surface No. 9 specified by 11 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	11.75	74.93
2	12.17	74.61
3	13.62	73.24
4	15.33	72.20
5	16.80	70.83
6	27.03	73.86
7	28.40	75.32
8	29.49	77.00
9	30.89	78.42
10	32.03	80.07
11	32.91	80.96

** Corrected JANBU FOS = 4.911 ** (Fo factor = 1.080)

Failure surface No.10 specified by 10 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	11.89	74.98
2	12.33	74.75
3	14.01	73.67
4	15.46	72.29
5	26.69	74.25
6	28.11	75.67
7	29.48	77.12

8	30.81	78.62
9	32.02	80.21
10	32.56	80.99

** Corrected JANBU FOS = 4.926 ** (Fo factor = 1.077)

 **
 ** Out of the 100 surfaces generated and analyzed by XSTABL, **
 ** 38 surfaces were found to have MISLEADING FOS values. **
 **

The following is a summary of the TEN most critical surfaces

Problem Description : APEX POND 2 RECLAIMED CROSS SECTION

	Modified JANBU FOS	Correction Factor	Initial x-coord (ft)	Terminal x-coord (ft)	Available Strength (lb)
1.	4.473	1.081	6.84	35.22	1.516E+04
2.	4.619	1.076	10.27	35.68	1.397E+04
3.	4.626	1.088	13.10	33.77	1.145E+04
4.	4.729	1.081	12.44	34.80	1.169E+04
5.	4.764	1.086	10.38	37.09	1.517E+04
6.	4.782	1.086	14.01	33.65	9.845E+03
7.	4.798	1.082	9.63	34.96	1.432E+04
8.	4.842	1.086	11.91	33.14	1.232E+04
9.	4.911	1.080	11.75	32.91	1.144E+04
10.	4.926	1.077	11.89	32.56	9.845E+03

* * * END OF FILE * * *

Appendix F

Runoff Evaluation and Erosion Protection Sizing Analyses

Appendix F – Runoff Evaluation and Erosion Protection Sizing Analysis

This appendix is separated into three sections containing results, data, and calculations for the:

- ▶ Runoff Evaluation
- ▶ Diversion Channel Flow and Erosional Stability Analyses
- ▶ Pond 2 Outslope Flow and Erosional Stability Analyses

for the selected Final Closure Plan alternative for Pond 2 at Hecla Mining Company's Apex Site near St. George, Utah.

Runoff Evaluation

Storm water runoff analyses were conducted on the selected cover system alternative for Pond 2 (the impoundment) at Hecla Mining Company's Apex Site, and on all contributory areas surrounding the impoundment.

Method of Analysis

Peak flows from the reclaimed impoundment surface and all surrounding areas upgradient of the site were estimated using the HEC-HMS computer program which was developed by the U.S. Army Corps of Engineers (USACE 2002). Factors which determine the peak flow rate from a basin are rainfall amount, distribution of precipitation, and runoff parameters of the basin (area, soil type, geometry, and slope).

The design event selected for the Apex Site was the 6-hour, 25-year event as it produced for more intense runoff (larger flow rates) than the 24-hour, 25-year event. Site specific precipitation amounts for both the 6-hour and 24-hour duration events with recurrence intervals of 25 years were determined from National Oceanic and Atmospheric Administration maps (WRCC 2003). Storm depths from the 6-hour and 24-hour events respectively were determined to be 1.9 and 2.4 inches. The rainfall event was distributed (in time) using the Soil Conservation Service (SCS) Type II distribution. Data and calculations showing selected soil types, rainfall distribution, and peak flows are included in this appendix after the References section.

Description of Basins

Runoff contributory to the main diversion channel (east side of the impoundment) was determined to derive from areas south of the impoundment and from the eastern half of the reclaimed impoundment surface. Contributory areas are outlined on Figure 1. An additional basin, consisting of a 50-foot wide strip on top of the reclaimed impoundment surface was used to assess erosional stability of the cover system outslope during the design storm event.

Soils in the vicinity of the Apex Site consist primarily of silts and clays, therefore, they were assumed to be in the Hydrologic Soil Group "C" which represents soils with moderately high runoff potential. The curve number parameter (83) was selected as the most suitable for this site from SCS values presented in Schwab (Schwab 1981). Basin parameters are listed in Table 1 below. Data and calculations, including a schematic of the basins showing flow directions and contributory areas are included after the References section.

Table 1 Summary of Basin Parameters						
Basin	Area (ac)	Area (sq mi)	SCS Curve Number	Hydraulic Length (ft)	Surface Slope (%)	Lag Time (min)
East 1	6.2	0.0097	83	1,300	12.2	6.1
East 2	9.7	0.0152	83	1,250	2.9	12.1
East 3	10.8	0.0169	83	1,100	13.2	5.1
East 4	5.6	0.0088	83	500	6.0	4.0
½ Pond 2	5.7	0.0045	83	280	1	6.2
50' strip	0.32	0.0005	83	280	1	6

Routing Parameters

Flood routing was used in the analysis of the total watershed area. The Muskingham routing method was utilized to include time effects (delay of peak flow) when routing flows from one location to another in the watershed. This method requires a channel constant x and a time constant K . Routing parameters used are summarized in Table 2 below.

Table 2 Muskingham Routing Parameters				
Reach	Velocity (ft/s)	Length (ft)	K (hrs)	x
East-1 to East-2	3.0	950	0.088	0.319
East-2 to East-4	3.0	500	0.046	0.319
East-3 to East-4	5.0	400	0.022	0.373

Selection of Design Storm Duration

A sensitivity analysis was performed to determine the appropriate duration of the 25-year storm event. A one-acre watershed was defined and subjected to both the 6-hour and 24-hour duration storm events. Peak runoff from the 6-hour event was 1.07 cubic feet per second (cfs) and peak runoff from the 24-hour event was 0.3 cfs. The 6-hour event had a larger peak runoff primarily due to the higher intensity of precipitation during the 6-hour event. Conservatively the higher peak runoff value (6-hour storm) was utilized for all further runoff and erosion protection sizing calculations.

Results

Peak flows from the 6-hour, 25-year, 1.9-inch storm event were calculated for the defined watershed and are listed in Table 3 below.

Table 3 List of Peak Flows (6-hour, 25-year event)	
Location	Peak Flow (cfs)
East-1	5.4
East-1 routed flow	5.2
East-2	6.8
East-1 and East-2 combined	12.0
Combined E-1 and E-2 routed to Junction-2	11.7
East-3	9.9
East-3 routed to Junction-2	9.9
½ of Pond 2 Surface	2.5
Junction-2	22.0
East-4	5.4
Junction-3	26.6
50-foot wide strip of Pond 2 surface	0.3

Diversion Channel Flow and Erosional Stability Analyses

Analysis of Flow Conditions

Flow conditions at selected locations along the diversion channel were assessed to determine if there was a requirement for erosion protection along the diversion channel or at the toe of the impoundment outslope. All data, figures, and calculations are included after the References section.

The constructed diversion channel begins at Hecla's southern property line, flows along the east side of the impoundment, and ends near the north side of the impoundment (Figure 9, MEI, 2003b). Channel left slope, right slope, bed slope, and width were determined from the conceptual diversion plan (MEI 2003b). A channel bed slope of 3.65% was calculated based on cross-sections at TP-4 and TP-2 shown in Figure 8 (MEI 2003b).

The peak flow calculated for all contributory drainages of 26.6 cfs was rounded up to 27 cfs. The actual location of this peak flow is near the east-central extent of the impoundment. For conservative evaluation of flow conditions within the diversion, this peak flow was utilized at all locations. A Manning's 'n' value of 0.03 was selected to represent a primarily bare, earthen channel (Schwab 1981). Flow conditions within the diversion channel are summarized in Table 4 below.

Table 4			
Summary of Flow Conditions in Diversion Channel			
Location	Channel Slope (%)	Depth of Flow (ft)	Velocity (ft/sec)
Cross section @ TP-4	3.65	0.63	4.4
Cross section @ TP-2	3.65	0.67	4.5

Tractive Force Analysis of Flow Velocities

The Temple shear stress method (Temple 1987) was used to evaluate erosion resistance of native soils along the channel bottom. This method uses soil characteristics to find the allowable stress that the soil can undergo and remain stable. Runoff characteristics derived from the 25-year, 6-hour storm were used to find the effective stress that runoff will impart to the soil surface. The effective stress must be less than the allowable soil stress for the channel surface to remain stable. Allowable soil stress was calculated based on limited laboratory test results from site soils sampled at depth (MEI 2003a). Allowable and effective stress calculations are given in the attachment. Results of shear stress analysis presented in

Table 5 below indicate that soils within the diversion should remain stable when subjected to the design storm.

Table 5 Summary of Temple Shear Stress Evaluation			
Location	Effective Shear (psf)	Allowable Shear (psf)	Allowable/Effective (ft/sec)
Cross section @ TP-4	0.0663	0.0894	1.35
Cross section @ TP-2	0.0706	0.0894	1.27

Given the uncertainty of using test results from samples intended to characterize potential borrow soils, and the current diversion channel conditions shown in site photos which indicate movement of bedload, it is likely that due to infrequent, large storm events some long-term movement of the diversion channel will occur. Therefore, it is recommended that gravel materials which are utilized to stabilize the impoundment outslope also be entrenched three feet beneath the final surrounding surface elevation to help protect the impoundment outslope from potential, long-term migration of the channel.

Diversion Channel Erosion Protection Analysis

Riprap or rock protection sizing analyses were performed for the entire length of the diversion channel. Two different methods of analysis were compared; the Safety Factors and Corps of Engineer's. The Safety Factors Method is most applicable at the intersection of the impoundment outslope and the diversion channel bottom, as it is applicable for evaluation of rock stability from flows parallel and adjacent to a slope (Abt 1988). The Safety Factors Method requires inputs of flow depth, channel slope, channel side slope, riprap angle of repose, and a trial D_{50} (median riprap size) to calculate the safety factor for a given rock size. For this analysis an angle of repose of 40 degrees was used. Results of the rock sizing calculations are given in Table 6 below.

Table 6 Summary of Diversion Channel Erosion Protection Calculations					
Location	Channel Slope (%)	Flow Depth (ft)	Flow Velocity (fps)	Safety Factors Method D_{50} (in)	C.O.E. Method D_{50} (in)
Cross section @ TP-4	3.65	0.63	4.4	3	1
Cross section @ TP-2	3.65	0.67	4.5	3	1

Based on rock sizes presented above, the placement of riprap with a D_{50} of at least three inches is recommended along the east-side toe of the impoundment. The rock should be placed at the toe and extend beneath the final ground surface of the diversion channel to a depth of approximately three feet.

Pond 2 Outslope Flow and Erosional Stability Analyses

To assess flow conditions and erosional stability of any given section of the reclaimed top surface and outslope of the impoundment, the peak flow from a sub-basin consisting of a 50-foot wide strip was calculated. The peak flow determined by the HEC-HMS model from the 25-year, 6-hour storm event is 0.28 cfs. This value was conservatively rounded up to 0.3 cfs. To account for variations and irregularities in the reclaimed impoundment surface due to grading imperfections and potential differential settlement, a conservative concentration factor of 3 was applied to this peak flow. In effect, the peak flow from a 150-foot wide strip was applied to the 50-foot wide strip. The resulting peak flow of 0.9 cfs was conservatively rounded up to 1.0 cfs. This peak flow of 1.0 cfs was analyzed using Manning's formula to determine depth and velocity of flow over the impoundment surface. A Manning's 'n' value of 0.40 was selected to model the roughness and resulting tortuous flow path produced by runoff flowing through the final gravel/soil surface layer. Results of the calculation for flow on the pile surface and outslope are listed in Table 7 below.

Table 7 Results of Flow Analysis by Manning's Formula		
Parameter	Top Surface	Outslope
Flow (cfs)	1	1
Mannings 'n'	0.04	0.04
Width (ft)	50	50
Slope (%)	1	28.6
Flow Depth (ft)	0.04	0.02
Flow Velocity (fps)	0.5	1.2

The outslope grade and corresponding flow depth and velocity were input into a rock-sizing calculation spreadsheet. Though the flow depth and velocity are minimal, the outslope gradient is fairly steep

(3.5h:1v). The Safety Factors Method, which is slope-dependant, was stable with a D_{50} of $\frac{3}{4}$ -inch. Analysis by the Corps of Engineer's method, which is velocity-dependant, showed that a factor of safety of greater than 1 was achieved when D_{50} values reached $\frac{1}{4}$ -inch to $\frac{1}{2}$ -inch. The Corps of Engineer's method also showed that with a D_{50} value of $\frac{3}{4}$ -inch or larger, the factor of safety was less than 1. The Corps of Engineer's Method was therefore determined to be inaccurate for this analysis as it showed that increasing rock size reduced erosional stability.

Based on the Safety Factors method, the use of rock material with a D_{50} of $\frac{3}{4}$ -inch or larger is recommended to ensure a factor of safety greater than 1.

As the previous diversion channel flow analysis indicated the impoundment outslope would be stable with a D_{50} of three inches, this same three inch material could be utilized for both outslope protection and toe protection. Typically, literature recommends the use of a lift thickness that is at least 1.5 times the D_{50} . Experience has shown that this can be difficult depending on the material and experience level of earthmoving personnel. A lift thickness of 2 times the D_{50} (6-inch lift) would facilitate ease of placement for the rock material.

References

- Abt 1988. Abt, S.R., R.J. Wittler, J.F. Ruff, D.L. LaGrone, M.S. Khattak, J.D. Nelson, N.E. Hinkle, and D.W. Less. "Development of Riprap Design Criteria by Riprap Testing in Flumes: Phase II," NUREG/CR-4651, prepared for Nuclear Regulatory Commission, September.
- MEI 2003a. Monster Engineering Inc., "Apex Site Potential Borrow Source Materials Investigation." Prepared for Hecla Mining Company, February 3.
- MEI 2003b. Monster Engineering Inc., "Apex Site – Pond 2 Conceptual Final Closure Alternatives, Draft Technical Memorandum." Prepared for Hecla Mining Company, March 25.
- Schwab 1981. Schwab, G.O., R.K. Frevert, T.W. Edminster, and K.K. Barnes. "Soil and Water Conservation Engineering." John Wiley and Sons, New York, New York.
- USACE 2002. U.S. Army Corps of Engineers. Hydrologic Engineering Center, Hydrologic Modeling System (HEC-HMS), Version 2.2.1, October 24.

WRCC 2003. Western Regional Climate Center. Web site www.wrc.dri.edu/pcpnfreq/. Presenting NOAA Atlas 2, Volume VI, Prepared by U.S. Department of Commerce, NOAA, NWS Office of Hydrology. Prepared for USDA Soil Conservation Service, Engineering Division.

Appendix F

Runoff Evaluation and Erosion Protection Sizing Analyses

Figures, Data, and Calculations

HECLA MINING COMPANY

COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 5/24/03	JOB TITLE APEX Pond 2 Closure	JOB NO.
CHK.	DATE		DIVISION
DWG. NO.		Runoff Cakes	SHEET 4 OF 14

Select Soil Conservation Service (SCS) Curve Number (CN)

Available information on site soils MEI 7/2003 Borrow Source Investigation

Shivwits Dam CL-ML

Heck TP-10-9' CL

→ Soil Group C Moderately High Runoff Potential Comprises shallow soils and soils containing considerable clay and colloids; below average infiltration after pre-saturation

Pasture or Range fair condition AMLI Group C	CN = 79
poor condition " "	86
	<hr/> 83

Ground cover is brush neither sparse or dense ∴ CN = 83

Storm Duration - Peak Runoff Evaluation

Use 1 acre area 0.0016 sq mi

CN = 83

$$T_c = 0.0195 L^{0.77} S^{-0.385}$$

where T_c = time of concentration (min)
 L = max length of flow (m) 64 m
 S = watershed gradient (1/1) 2% = .02

$$= 0.0195 \cdot 64^{.77} \cdot 0.02^{-.385}$$

$$= 2.2 \text{ min}$$

25YR 6HR 1.9" peak Q = 1.07 cfs SCS Type II dist see p 51
 24HR 2.4" peak Q = 0.3 cfs " " " "

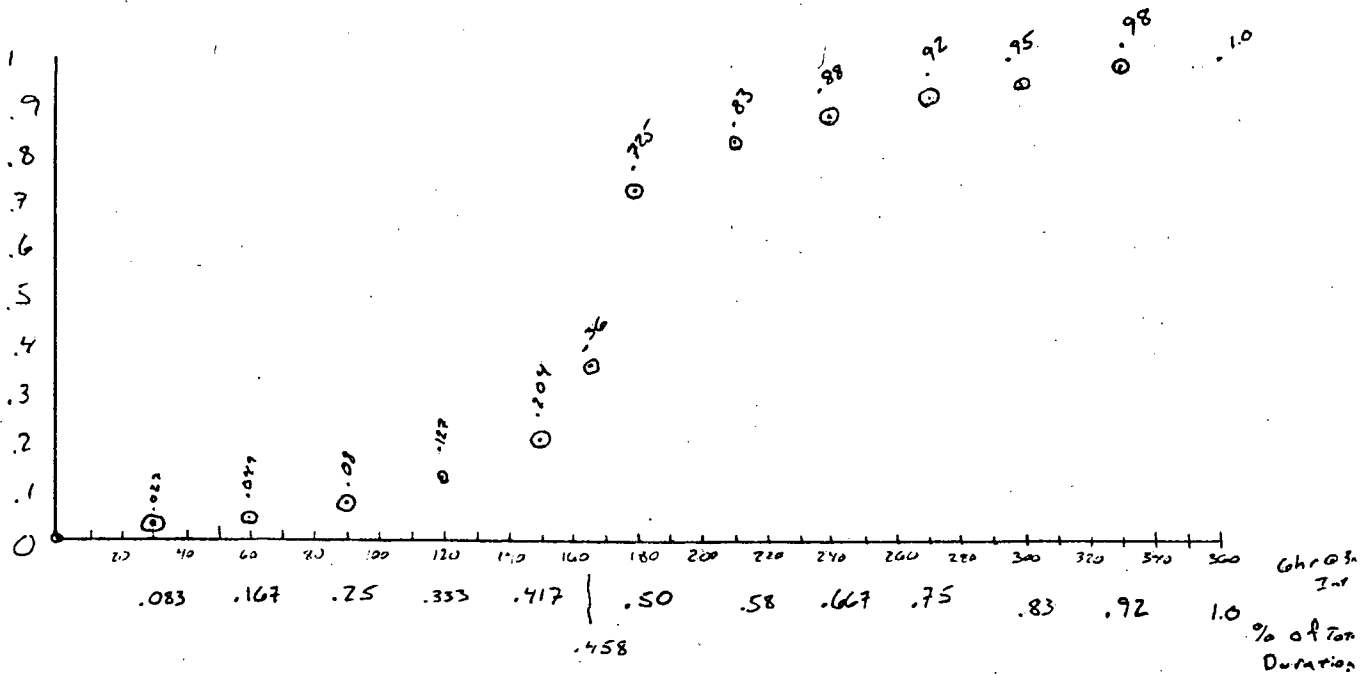
∴ utilize 6HR storm duration & SCS Type II distribution for runoff calculations

HECLA MINING COMPANY

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BY DTM	DATE 5/26/03	JOB TITLE APEX Pond 2	JOB NO.
CHK.	DATE	Runoff Calcs	DIVISION
DWG. NO.			SHEET 5 OF 14

SCS Type II Rainfall Distribution



HEC HMS	6 HR Storm			24 HR Storm		
Time of Storm	% of Time	TYPE II ratio	depth(in)	% of total	TYPE II ratio	depth(in)
5min	.0139	.0036	.007	.0035	.001	.002
15min	.0417	.011	.021	.0104	.0028	.007
1hr	.1667	.049	.073	.0417	.0110	.026
2	.3333	.129	.24	.083	.023	.055
3	.5	.225	.38	.125	.035	.084
6	1.0	1.0	1.9	.25	.080	.19
12	—	—	—	.5	.725	1.74
24	—	—	—	1.0	1.0	2.4

254R 6HR = 1.9" 360min

254R 24HR = 2.4" 1440min

A00147

HMS * Summary of Results

Project : Hecla_APEX

Run Name : Run 1

Start of Run : 01Jun03 1200 Basin Model : Basin 1

End of Run : 02Jun03 1200 Met. Model : Met 1

Execution Time : 26May03 1733 Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
-----------------------	----------------------------	-----------------	----------------------	-----------------------------

Subbasin-1

1.0676

01 Jun 03 1630

0.053564

0.002

peak flow from 254R GMR 1.9 IN Event
w/ SCS Type II Distribution

HMS * Summary of Results

Project : Hecla_APEX

Run Name : Run 1

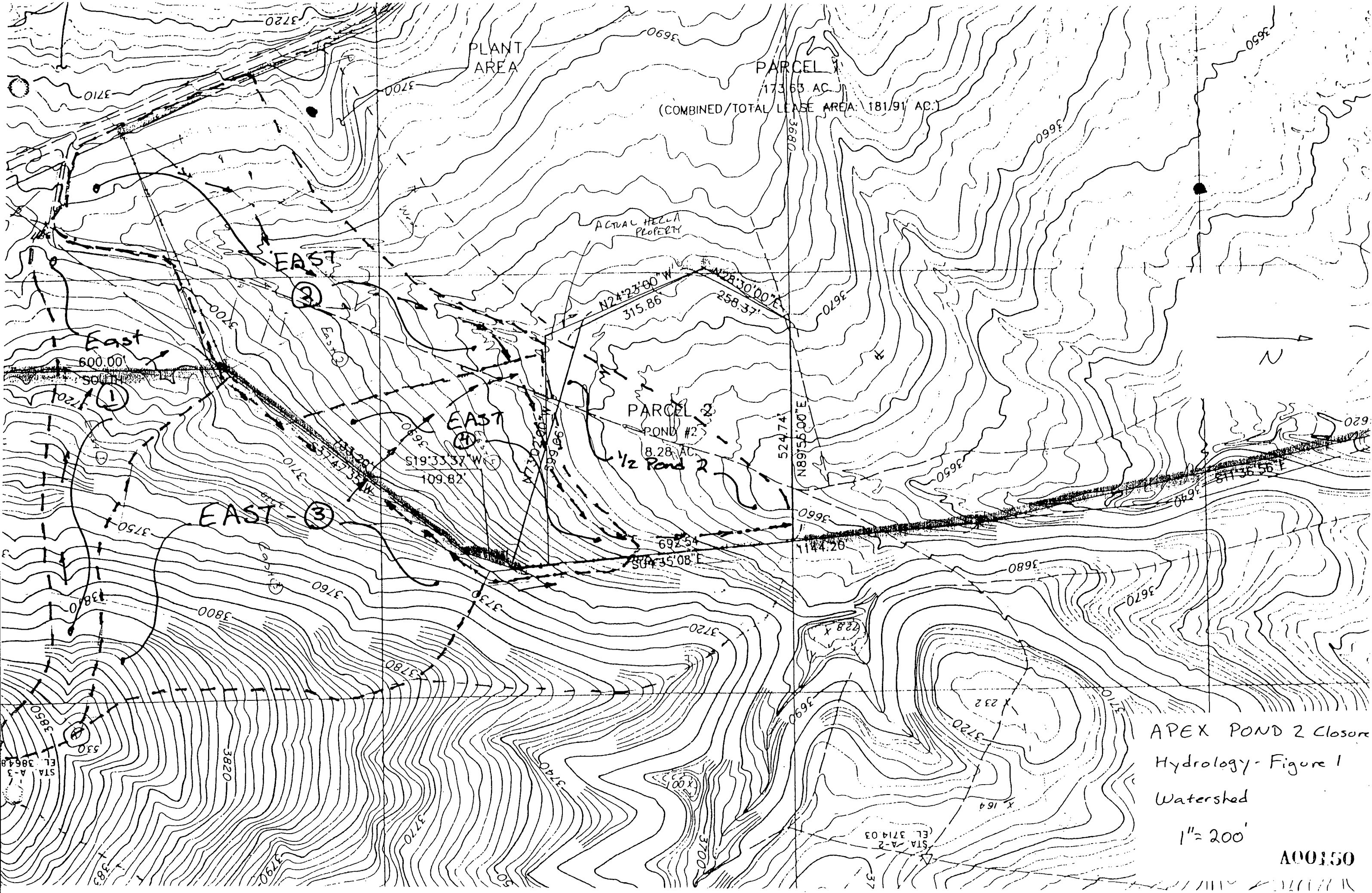
Start of Run : 01Jun03 1200 Basin Model : Basin 1

End of Run : 02Jun03 1200 Mat. Model : Mat 1

Execution Time : 26May03 1727 Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
Subbasin-1	0.32412	02 Jun 03 0600	0.083558	0.002

→ peak flow from 25HR 24HR 2.4IN Event
w/ SCS Type II distribution



APEX POND 2 Closure
Hydrology - Figure 1
Watershed
1" = 200'

HECLA MINING COMPANY

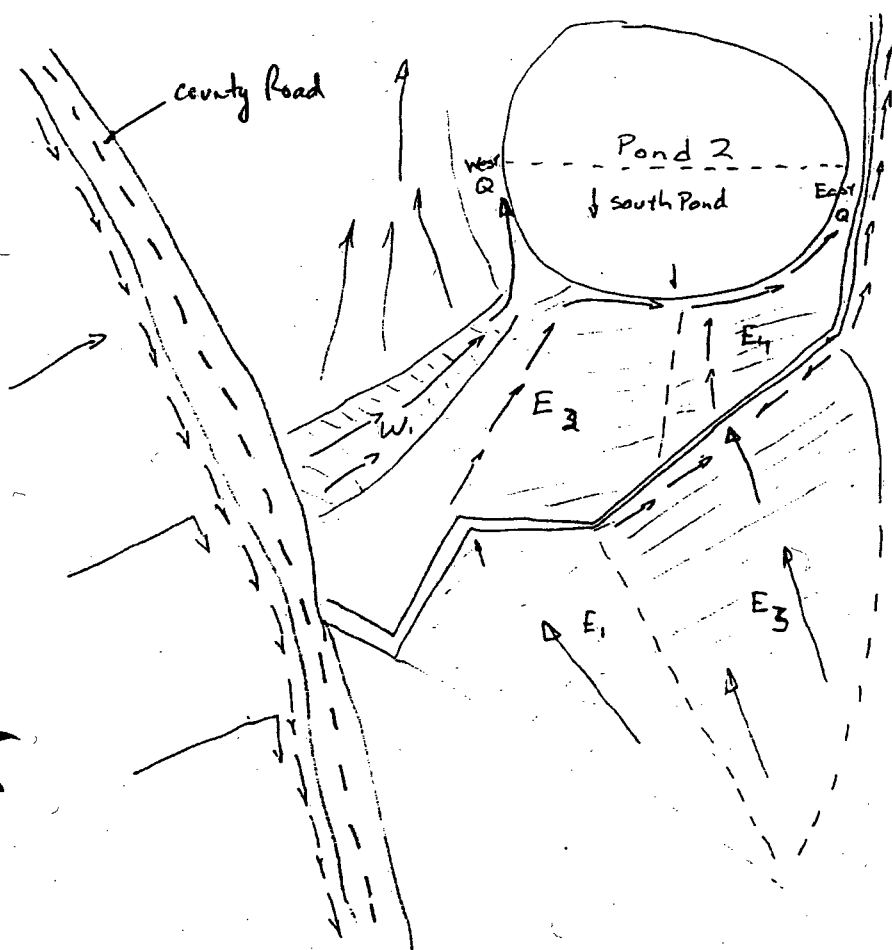
COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 5/26/03	JOB TITLE APEX Pond 2 Closure	JOB NO.
CHK.	DATE		DIVISION
DWG. NO.		Runoff Calc	SHEET 1 OF 14

Assess Runoff Hydrology of Pond 2

- Information from others is that drainage from the hillside west of the road located ~1,000 ft west of Pond #2 is captured by the road/sorrowditch and drains away to the south.
- Drainage from the plant areas flows primarily north and away from pond #2
- Drainage from the bires east of pond #2 is also captured by access road/ditch and diverted.
- Drainages that contribute to flow that may impinge on pond #2 are located south of the pond.

Schematic



Drainages
1) West 2) East

Sub Basins

1) West 1) East₁
2) East₂
3) East₃
4) East₄

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BY DTA	DATE 5/26/03	JOB TITLE APER Pond 2 Closure	JOB NO.
CHK.	DATE	Runoff Calc	DIVISION
DWG. NO.			SHEET 2 OF 14

Calculate Sub-Basin Areas (from 1"=200' Site Map)

$$\text{West } (550 \text{ ft} \times 200) + 400 \times \left(\frac{180 \times 50}{2} \right) = 156,000 \text{ ft}^2 = \underline{3.6 \text{ ac}}$$

Exclude; runoff detained w/in OMG Pond DTAU, 103

$$\text{East 1: } \frac{1}{2} 150 \cdot 220 + 270 \cdot 120 + 360 \cdot 190 + 190 \cdot 310 + 260 \cdot 360 \\ = 269,800 \text{ ft}^2 = \underline{6.2 \text{ ac}}$$

$$\text{East 2: } 320 \cdot 500 + 300 \cdot 450 + 180 \cdot 520 + \frac{1}{2} 550 \cdot 120 \\ = 421,600 \text{ ft}^2 = \underline{9.7 \text{ ac}}$$

$$\text{East 3: } \frac{1}{2} 280 \cdot 770 + 290 \cdot 850 + \frac{1}{2} 280 \cdot 830 \\ = 470,500 \text{ ft}^2 = \underline{10.8 \text{ ac}}$$

$$\text{East 4: } 520 \cdot 270 + 230 \cdot 400 = 242,800 = \underline{5.6 \text{ ac}}$$

Sub-Basin	Area (ac)
West	3.6
East 1	6.2
East 2	9.7
East 3	10.8
East 4	5.6
East Sub-total	32.3
All	35.9

HMS Area sq mi.

.0056

.0097

.0152

.0169

.0038

Storm Intensity

evaluation use 1 ac .0016

A00152

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BY DTA	DATE 6/1/03	JOB TITLE APEX POND 2 CLOSURE	JOB NO.
CHK.	DATE	Runoff Calcs	DIVISION
DWG. NO.			SHEET 3 OF 14

Pond 2 Runoff

Area = 5.7 acres with domed surface

→ 1/2 of surface will contribute flow to the diversion along the south side of Pond 2

→ North half runoff will be overland (not channeled) flow

Area = 2.9 acres = 0.0045 sq mi

SCS CN = 83

Basin slope = 1%

Drainage length = 280 ft (typ)

Lag Time = 0.904 hrs

HECLA MINING COMPANY

COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 5/26/03	JOB TITLE APEX Pond 2 Closure	JOB NO.
CHK.	DATE	Runoff Calcs	DIVISION
DWG. NO.			SHEET 8 OF 14

Sub Basin Characteristics

ID	Name	Area (ac)	Area (mi ²)	Hyd L (ft)	Slope (ft/ft)	SCS Lag Time (min)	cal on P8
1	West	3.6	.0056	920	$\frac{3712-3674}{L} = 0.041$	8	
2	East-1	6.2	.0097	1,300	$\frac{3765-3706}{L} = 0.122$	6	
3	East-2	9.7	.0152	1,250	$\frac{3710-3674}{L} = 0.029$	12	
4	East-3	10.8	.0169	1,100	$\frac{3850-3705}{L} = 0.132$	5	
5	East-4	5.6	.0088	500	$\frac{3705-3675}{L} = 0.060$	4	

Routing Parameters Muskingum 'K & X'

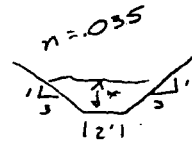
West - flows to west; no combination, no routing

East-1 route through East-2 950 ft @ 10/480 2.1% ~ 5.5 cfs

East-2 route through East-4 along south edge of Pond 2
500 ft @ ~1% 12.3 cfs

East-3 route through East-4
400 ft @ 5% ~ 9.9 cfs

all w/



Route	Q (cfs)	Slope (ft/ft)	Depth* (ft)	Velocity (fps)	K hrs	X
E-1 to E-2	5.5	.021	90.51	3.0	.088	.319
E-2 to E-4	12.3	.01	0.91	2.9	.046	.319
E-3 to E-4	9.9	.05	0.55	4.9	.022	.373

K & X calculated on spreadsheet see p 12/
velocity calculated on spreadsheet see p 13/

A00154

THIS SPREADSHEET CALCULATES LAG TIME FOR BASINS.
IT CAN BE USED FOR HEC-1 ANALYSES.

$$\text{LAG TIME} = L^{0.8} \cdot (S+1)^{0.7} / 1900 \cdot Y^{0.5}$$

L = GREATEST SLOPE LENGTH (FEET)

$$S = (1000/n) - 10 = 2.05$$

$$n = \text{CURVE NUMBER} = 83$$

Y = AVERAGE BASIN SLOPE

BASIN	L (FT)	Y (%)	LAG TIME (HRS)	LAG TIME (MIN)
APEX Pond 2 Closure				
South Pond	280	1	0.104	6.251
East-1	1300	12.2	0.102	6.112
East-2	1250	2.9	0.202	12.149
East-3	1100	13.2	0.086	5.141
East-4	500	6	0.068	4.058

HMS * Summary of Results

Project : Hecla_APEX

Run Name : Run 1

Start of Run : 01Jun03 1200 Basin Model : Basin 1

End of Run : 02Jun03 1200 Met. Model : Met 1

Execution Time : 26May03 1813 Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
West	2.9026	01 Jun 03 1634	0.18747	0.006
East-2	6.8140	01 Jun 03 1636	0.50882	0.015
East-4	5.3962	01 Jun 03 1631	0.29459	0.009
East-1	5.4478	01 Jun 03 1632	0.32472	0.010
East-3	9.9064	01 Jun 03 1632	0.56572	0.017

Calculation of basin peak flows

• no reaches or routing included.

P10/14

A00156

Trial and Error method for calculating depth and the corresponding velocity using Manning's Equation.

Flow = 9.9 cfs
Manning's n = 0.035
Bottom width = 2 ft
Right Side Slope, z:1 = 3
Left Side Slope, z:1 = 3
Channel Slope = 0.05 ft/ft

Trapezoidal Channel

Assumed Depth (ft)	Calculated Depth (ft)	Average Velocity (ft/s)	Type of Flow	Froude Number	Cross-Sectional Area	Top Width	Hydraulic Radius
1.00	0.29						
0.65	0.47						
0.56	0.55						
0.55	0.55	4.89	SUPERCritical	1.3968	2.02	5.32	0.15
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Sample velocity calc
for determination of
Muskingham K_s

P 11/14

THIS SPREAD SHEET CAN BE USED TO CALCULATE
MUSKINGHAM ROUTING NUMBERS "K" AND "X"

$$X = (0.5 \cdot V) / (1.7 + V) \quad 0 < X < 0.5$$

$$K = L / V / 3600 \quad (\text{SEC TO HRS})$$

V = ESTIMATED VELOCITY FOR FIRST TRIAL (BARFIELD)
AND CALCULATED VELOCITY AFTER RUNNING HEC.

L = CHANNEL LENGTH

REACH	VELOCITY (FT/S)	LENGTH (FT)	K (HRS)	X
e1-e2	3	950	0.088	0.319
e2-e4	3	500	0.046	0.319
e3-e4	5	400	0.022	0.373
N1-N2	6	400	0.019	0.390
N1-N2	7	400	0.016	0.402
N1-N2	8	400	0.014	0.412
N1-N2	9	400	0.012	0.421
N1-N2	10	400	0.011	0.427
N1-N2	11	400	0.010	0.433
N1-N2	12	400	0.009	0.438
N1-N2	13	400	0.009	0.442
N1-N2	14	400	0.008	0.446

THE TABLE BELOW WILL SHOW IF THERE IS ANY
POTENTIAL ROUTING INSTABILITY

$$(K \cdot 60) / (NMIN \cdot NSTPS) = MT \quad \text{IDDL TER}$$

MUST BE BETWEEN THE FOLLOWING TWO LIMITS:

$$\text{LOWER LIMIT} = 1 / (2(1-X)) = LL$$

$$\text{UPPER LIMIT} = 1 / (2X) = UL$$

$$NSTPS = \text{Number of subreaches}$$

$$NMIN = \text{Number of times in computational interval}$$

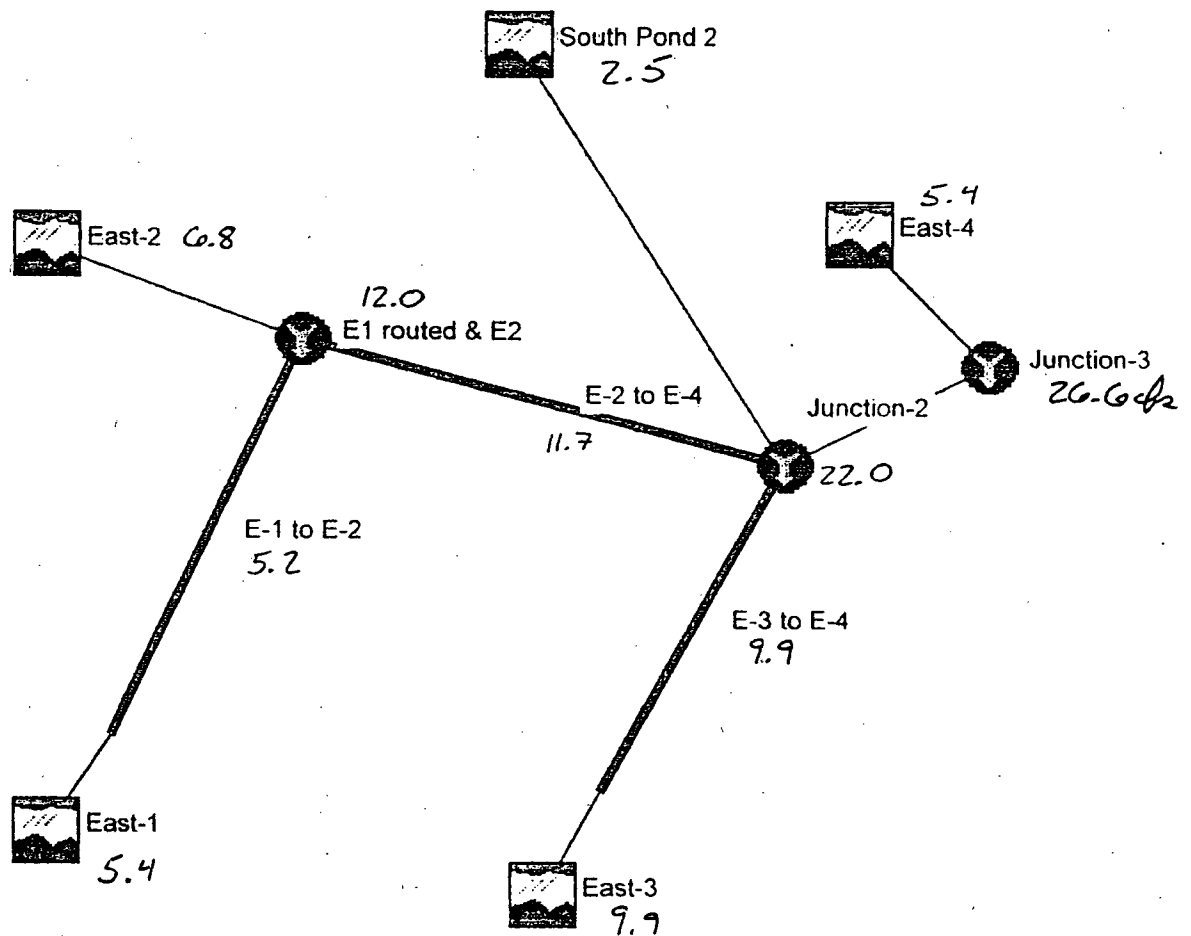
IF THERE IS INSTABILITY, EITHER REDUCE NSTPS OR NMIN.

VELOCITY (FT/S)	K (HRS)	X	LL	UL	MT
3	0.088	0.319	0.734	1.57	2.64
3	0.046	0.319	0.734	1.57	1.39
5	0.022	0.373	0.798	1.34	0.67
6	0.019	0.390	0.819	1.28	0.56
7	0.016	0.402	0.837	1.24	0.48
8	0.014	0.412	0.851	1.21	0.42
9	0.012	0.421	0.863	1.19	0.37
10	0.011	0.427	0.873	1.17	0.33
11	0.010	0.433	0.882	1.15	0.30
12	0.009	0.438	0.890	1.14	0.28
13	0.009	0.442	0.896	1.13	0.26
14	0.008	0.446	0.902	1.12	0.24

A00158

p12/4

254R 6HR 1.9IN storm Event Peak Flows (cfs)



HMS * Summary of Results

Project : Hecia_APEX

Run Name : Run 1

Start of Run : 01Jun03 1200 Basin Model : Basin 1

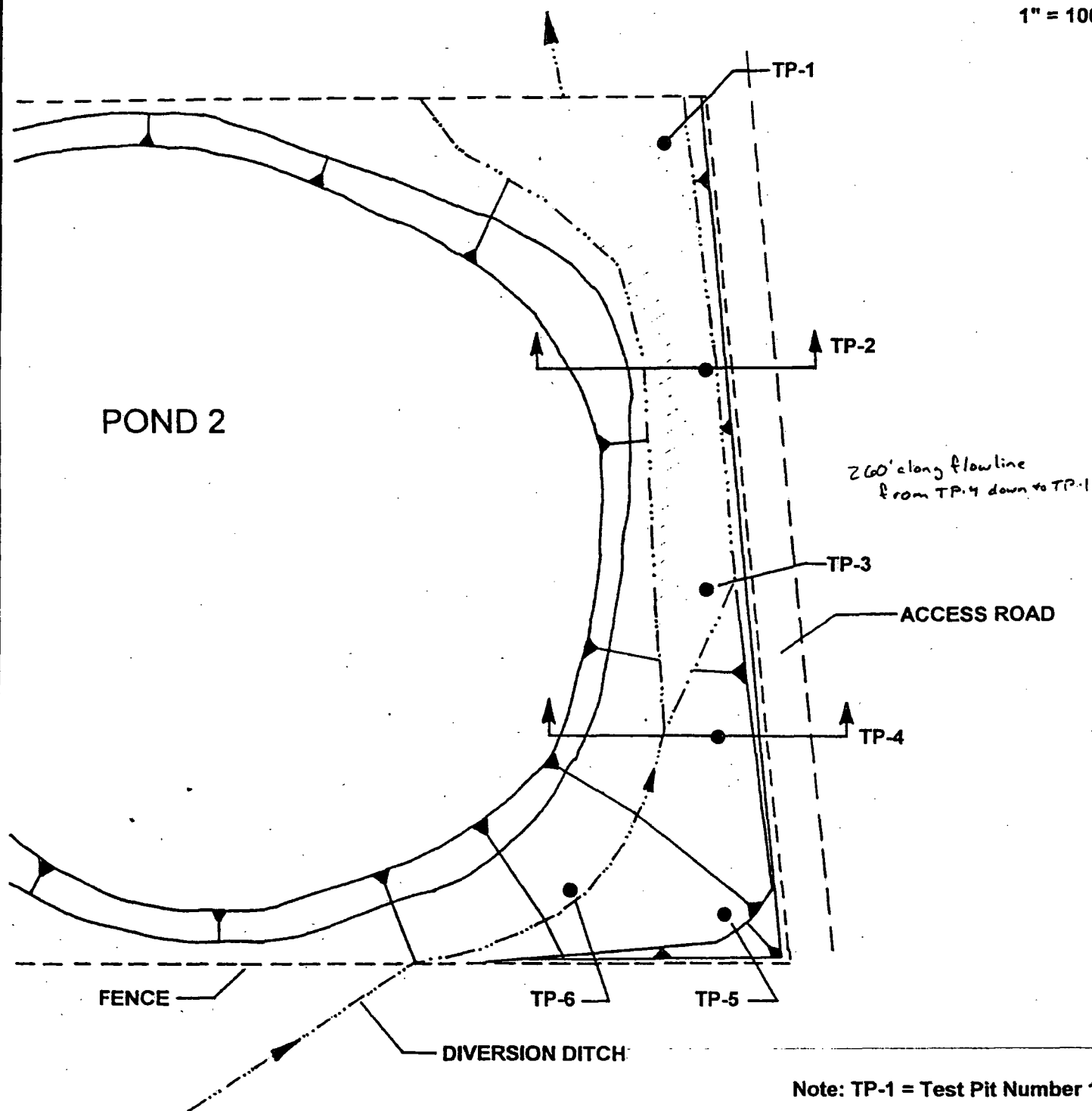
End of Run : 02Jun03 1200 Met. Model : Met 1

Execution Time : 01Jun03 1445 Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
East-1	5.4478	01 Jun 03 1632	0.32472	0.010
E-1 to E-2	5.1581	01 Jun 03 1636	0.32472	0.010
East-2	6.8140	01 Jun 03 1636	0.50882	0.015
E1 routed & E2	11.972	01 Jun 03 1636	0.83354	0.025
E-2 to E-4	11.727	01 Jun 03 1639	0.83354	0.025
East-3	9.9064	01 Jun 03 1632	0.56572	0.017
E-3 to E-4	9.8512	01 Jun 03 1633	0.56572	0.017
South Pond 2	2.5274	01 Jun 03 1632	0.15065	0.004
Junction-2	22.043	01 Jun 03 1634	1.5499	0.046
East-4	5.3962	01 Jun 03 1631	0.29459	0.009
Junction-3	26.643	01 Jun 03 1633	1.8445	0.055



1" = 100'



Note: TP-1 = Test Pit Number 1

PROJECT APEX
LOCATION St. George, Utah
DATE 3/15/03

Figure 9
Alternative 1 - Channel Excavation Plan View

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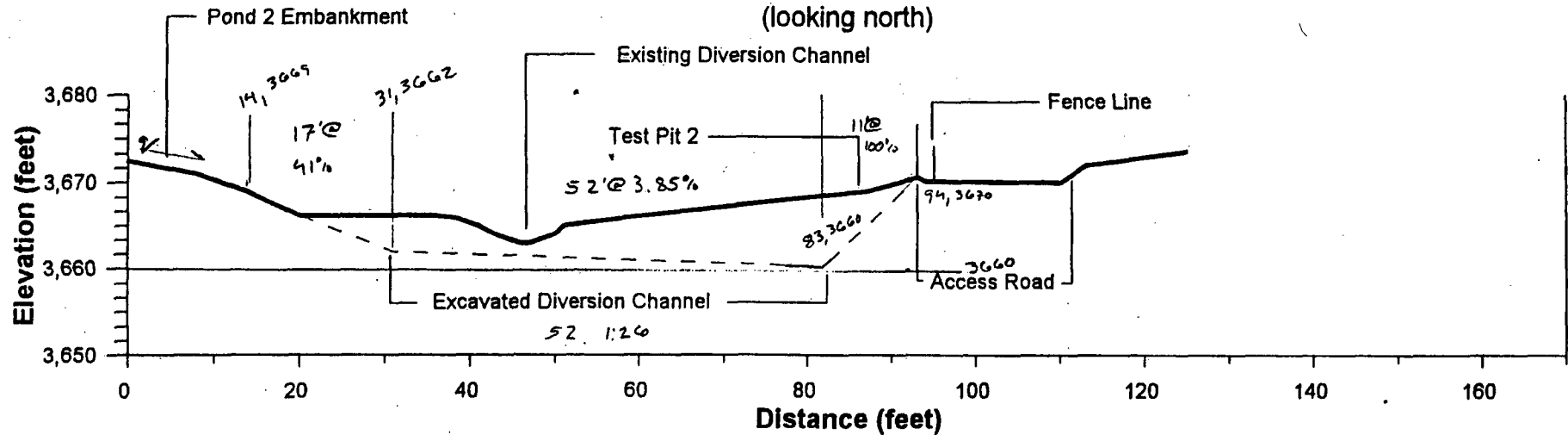
Monster Engineering Inc.

Prepared for:

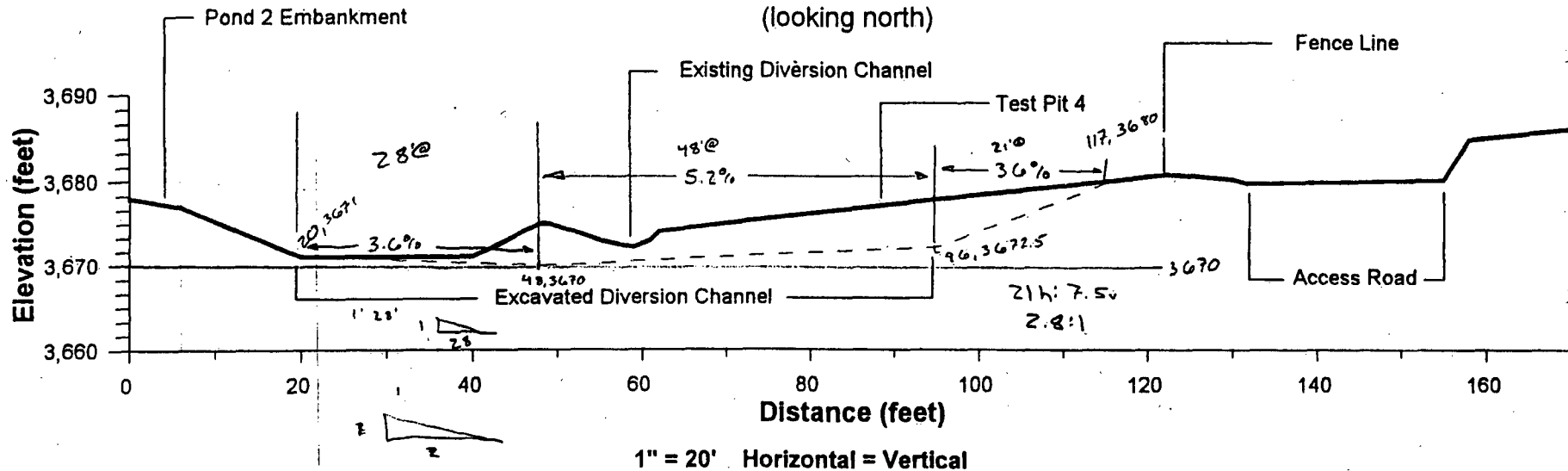


A00161

Channel Cross-section at TP- 2 (looking north)



Channel Cross-section at TP- 4 (looking north)



PROJECT APEX
LOCATION St. George, Utah
DATE 3/15/03

Figure 8
Alternative 1 - Borrow Area / Channel Excavation Cross Sections

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Prepared by:

Prepared for:

Mountain Construction Co.



HECLA MINING COMPANY

COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 6/22/03	JOB TITLE APEX POND 2 Closure	JOB NO.
CHK.	DATE	Reclaimed South Ditch	DIVISION
DWG. NO.			SHEET 1 OF 7

- HEC-HMS analysis of 254R GMR storm event gave a peak flow at southside of 22cfs and peak flow at southeast side of 26.6cfs
- Utilize peak flow of 27cfs
- Geometry of diversion given by Figure 8 (@ TP-2 & TP-4) MCI closure alternatives

Section	left slope	rt slope	invert elev	distance between TP-2 & TP-4
TP-2 d/s	3.85% 4:26	1:1 100%	3660.5	TP-2 = 260' slope
TP-4 u/s	3.6 1:28h	36% 28h:1v	3670 28h:1v = 9.5'/260' = 3.65%	

- Manning's n value Schwab (1981)
use $n = 0.030$

- Spreadsheet analysis of depth & velocity see p 2/ & 3/

Section	Depth (ft)	Velocity (fps)
TP-4	0.63	4.4
TP-2	0.67	4.5

Soil shear stress

soil grain roughness

Sample TP-1 68% minus No 200

$$D_{75} = 0.1m = 0.0039in$$

$$n_s = \frac{(D_{75})^{1/4}}{39} \quad n_s = 0.0102$$

shear stress cont'd on p 4/

Trial and Error method for calculating depth and the corresponding velocity using Manning's Equation

Flow = 27 cfs
Manning's n = 0.03
Left Side Slope Z:1= 28
Right side slope Z:1= 2.8
Channel Slope = 0.0365 ft/ft

@ TP-4

Triangular Channel

Assumed Depth (ft)	Calculated Depth (ft)	Average Velocity (ft/s)	Type of Flow
1000.00	0.05		
0.05	1.43		
1.43	0.48		
0.48	0.69		
0.69	0.61		
0.61	0.64		
0.64	0.63		
0.63	0.63	4.4	SUBCRITICAL FLOW
	#DIV/0!	#DIV/0!	#DIV/0!

Trial and Error method for calculating depth and the corresponding velocity using Manning's Equation

Flow = 27 cfs
Manning's n = 0.03
Left Side Slope Z:1= 26
Right side slope Z:1= 1
Channel Slope = 0.0365 ft/ft

@ TP-2

Triangular Channel

Assumed Depth (ft)	Calculated Depth (ft)	Average Velocity (ft/s)	Type of Flow
1000.00	0.06		
0.06	1.50		
1.50	0.51		
0.51	0.73		
0.73	0.65		
0.65	0.67		
0.67	0.66		
0.66	0.67		
0.67	0.67		

4.5 SUBCRITICAL FLOW

HECLA MINING COMPANY

COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 4/2/03	JOB TITLE APEX POND 2 closure	JOB NO.
CHK.	DATE	South Ditch Analysis	DIVISION
DWG. NO.			SHEET 4 OF 7

Erosional Stability of Channel Soils By Temple Shear Stress Method (1987)

$$\tau_a = \tau_{ab} C_e^2$$

τ_a = allowable shear stress (psf)

τ = atto basis allowable shear stress (psf)

C_e = soil parameter = $A - B_e$

τ_{ab} silts & clays = 0.076

& $C_e = 1.42 - 0.61e$

$$e = \text{void ratio} = \frac{V_v}{V_s} = \frac{V_a + W_w}{W_s}$$

$V_T = 1.0 \text{ ft}^3$	0.22	Air		
	0.356	Water	$W_w = 8.515$	\uparrow
	0.644	Solids	$W_s = 106.515$	\downarrow

Assume soil w/in channel $\gamma_m = 115 \text{ pcf}$ @ $w = 8\%$ $\gamma_d = 106.5 \text{ pcf}$

$$V_w = \frac{W_w}{\gamma_w} = \frac{8.515}{\frac{62.4}{1+0.08}} = 0.136 \text{ ft}^3$$

$$V_s = \frac{W_s}{G_s \gamma_w} \quad \text{assume } G_s = 2.65 \quad V_s = \frac{106.515}{(62.4 \text{ pcf}) 2.65} = 0.644$$

$$e = \frac{0.356}{0.644} = 0.55$$

→ Spread sheet calculation see p 4/

All calculated values τ_a/τ_{eff} are > 1 indicating stability of soils within the channel should not be dislodged by hydraulic forces exerted under the 254R GHR storm

However, limited Site, surface soil information is available. Rather than creating an entrenched armoured channel, the more effective method to ensuring pile stability would be to entrench slope erosion materials below the existing/reclaimed ground surface level.

SPREADSHEET TO CALCULATE ALLOWABLE AND EFFECTIVE
SHEAR STRESSES (Temple et al., 1987)

PROJECT APEX Pond 2 Closure
AREA South Channel
DATE 6/22/2003

<===== EQUATION===== >

$$Ta = Tab * Ce^2$$

Ta = allowable shear stress (psf)

Tab = basis allowable shear stress (psf)

Ce = soil parameter = A-Be

e = void ratio

NOTE: Equation will vary depending on soil type
check Temple et al.

<===== CALCULATION===== >

input values

output value

A	1.42	Ce	1.0845
B	0.61		
e	0.55	Ta	0.0894
Tab	0.076		

<===== EQUATION===== >

Effective Shear Stresses

$$Teff = YDS(1-Cf)(ns/n)^2$$

Teff = effective shear stress (psf)

Y = unit weight of water (pcf)

D = depth of flow (ft)

S = bed slope (ft/ft)

Cf = vegetal cover factor

ns = soil grain roughness factor = $D75^{1/6}/39$

n = Manning's "n"

Conquista:

Cf good cover = 0.9

Cf bare soil = 0.5

<===== CALCULATION===== >

SECTION	Y	D	S	Cf	ns	n	Teff	Ta/Teff
TP-4	62.4	0.63	0.0365	0.6	0.0102	0.03	0.0663	1.347
TP-2	62.4	0.67	0.0365	0.6	0.0102	0.03	0.0706	1.267

RIP RAP CALCULATION USING: SAFETY FACTORS AND CORPS OF ENGINEERS METHODS

Cross-Section TP-4

WATER DEPTH=? (ft.)

0.63

RISE/RUN RADS DEGREES

BED SLOPE=? (RISE/RUN) 0.0365 0.036 2.09

BANK SLOPE=? (RISE/RUN) *left (Pond side)* 0.036 0.036 2.06

ANGLE OF REPOSE=? (DEGREES) 0.698 40.00

VEL. = ? 4.4 (fps)

CORPS OF ENGINEERS METHOD

D-50 (ft)	DEPTH (ft)	T	N	B (RADS)	B DEGREES	N'	SAFETY FACTOR	VEL. (fps)	T	T	T	SF
		TRACTION FORCE	STABILITY PARAMETER						NEEDED FORCE	AVAILABLE	SLOPE	
0.04	0.63	1.09	5.56	1.56	89.12	5.56	0.18	4.4	0.22	0.16	0.164	0.75
0.06	0.63	1.09	3.71	1.55	88.69	3.71	0.27	4.4	0.26	0.25	0.246	0.96
0.08 1"	0.63	1.09	2.78	1.54	88.26	2.78	0.36	4.4	0.29	0.33	0.328	1.13
0.17	0.63	1.09	1.31	1.51	86.37	1.31	0.76	4.4	0.41	0.70	0.697	1.68
0.25 3"	0.63	1.09	0.89	1.48	84.75	0.89	1.12	4.4	0.51	1.03	1.024	1.99
0.33	0.63	1.09	0.67	1.45	83.18	0.67	1.47	4.4	0.61	1.35	1.352	2.22
0.42	0.63	1.09	0.53	1.42	81.48	0.53	1.87	4.4	0.71	1.72	1.721	2.41
0.50	0.63	1.09	0.44	1.40	80.03	0.44	2.22	4.4	0.81	2.05	2.049	2.54
0.12	0.63	1.09	1.85	1.53	87.41	1.85	0.54	4.4	0.35	0.49	0.492	1.41

RIP RAP CALCULATION USING: SAFETY FACTORS AND CORPS OF ENGINEERS METHODS

Cross-Section TP-2

WATER DEPTH=? (ft.) 0.67

RISE/RUN RADS DEGREES

BED SLOPE=? (RISE/RUN) 0.0365 0.036 2.09

BANK SLOPE=? (RISE/RUN) *left (Pond 2 side)* 0.0385 0.038 2.20

ANGLE OF REPOSE=? (DEGREES) 0.698 40.00

VEL. = ? 4.5 (fps)

CORPS OF ENGINEERS METHOD

D-50 (ft)	DEPTH (ft)	T TRACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR	VEL. (fps)	T NEEDED TRACTIVE FORCE	T AVAILABLE	T SLOPE	SF
0.04	0.67	1.16	5.91	1.56	89.12	5.91	0.17	4.5	0.22	0.16	0.164	0.74
0.06	0.67	1.16	3.94	1.55	88.68	3.94	0.25	4.5	0.26	0.25	0.246	0.94
0.08	0.67	1.16	2.96	1.54	88.25	2.96	0.34	4.5	0.29	0.33	0.328	1.11
0.17	0.67	1.16	1.39	1.51	86.34	1.39	0.72	4.5	0.42	0.70	0.696	1.66
0.25	0.67	1.16	0.95	1.48	84.70	0.95	1.05	3" 4.5	0.52	1.03	1.024	1.98
0.33	0.67	1.16	0.72	1.45	83.12	0.72	1.39	4.5	0.61	1.35	1.352	2.21
0.42	0.67	1.16	0.56	1.42	81.40	0.56	1.76	4.5	0.72	1.72	1.721	2.41
0.50	0.67	1.16	0.47	1.39	79.93	0.47	2.09	4.5	0.81	2.05	2.048	2.54

HECLA MINING COMPANY

COEUR D'ALENE, IDAHO 83814

BY DTM	DATE 9/22/03	JOB TITLE APEX POND 2 CLOSURE	JOB NO.
CHK.	DATE	POND 2 Runoff/Erosional Stability	DIVISION
DWG. NO.			SHEET 1 OF 5

Consider a 50-ft wide strip of pond surface

length of top surface = 280' @ 1%

Area = 280' x 50' = 14,000 sq ft = 0.32 ac = 0.0005 sq mi

use CN = 83 rock/gravel surface underlain by compacted fill

increase over rock layer value for added conservatism to runoff/erosional stability calculations

SCS Lag Time = 6 minutes

→ 25 YR GHR 1.9" storm peak runoff = 0.28 say 0.3 cfs

To account for variations in surface grading & resulting topography
use concentration factor

∴ peak flow from 50' unit width = 3 x 0.3 cfs = 0.9 cfs → 1 cfs

or $\frac{1 \text{ cfs}}{50 \text{ ft}} = 0.02 \text{ cfs/ft}$

Reclaimed Pond 2 outslopes 3.5:1 or 28.6%

→ use Manning spreadsheet to calculate depth of flow & velocity @ 1% & 28.6% slopes

$n = 0.04$ flow w/in rock cover

$q = 1 \text{ cfs}$

$n = 0.04$

$B_w = 50'$

$S = 1\%$

Depth = 0.04 ft

Vel = 0.5 fps

$S = 28.6\%$

Depth = 0.02 ft

Vel = 1.25 fps

Outslope rock sizes

Safety Factors $\geq 3/4"$ D50

COE Method $1/4"$ & $1/2"$ D50 are ok

$\geq 3/4"$ method calls blow up

A00170

HMS * Summary of Results

Project : Hecla_APEX

Run Name : Run 2

Start of Run : 01Jun03 1200 Basin Model : Pond 2 unit runoff
End of Run : 02Jun03 1200 Met. Model : Met 1
Execution Time : 03Jun03 2038 Control Specs : Control 1

Hydrologic Element	Discharge Peak (cfs)	Time of Peak	Volume (ac ft)	Drainage Area (sq mi)
-----------------------	----------------------------	-----------------	----------------------	-----------------------------

50' width unit runof	0.28083	01 Jun 03 1632	0.016739	0.001
----------------------	---------	----------------	----------	-------

↳ decimal resolution
to 3 decimal places
actual area used in
model = 0.000539 mi

Trial and Error method for calculating depth and the corresponding velocity using Manning's Equation.

Flow = 1 cfs
Manning's n = 0.04
Bottom width = 50 ft
Right Side Slope, z:1 = 0.01
Left Side Slope, z:1 = 0.01
Channel Slope = 0.286 ft/ft

Trapezoidal Channel

Assumed Depth (ft)	Calculated Depth (ft)	Average Velocity (ft/s)	Type of Flow	Froude Number	Cross- Sectional Area	Top Width	Hydraulic Radius
1.00	0.00						
0.50	0.00						
0.25	0.00						
0.13	0.00						
0.07	0.01						
0.04	0.01						
0.02	0.01						
0.02	0.01						
0.02	0.02	1.25	SUPERCRTIC	1.7556	0.78	50.00	0.01

$P^{3/5}$

100172

Trial and Error method for calculating depth and the corresponding velocity using Manning's Equation.

Flow = 1 cfs
Manning's n = 0.04
Bottom width = 50 ft
Right Side Slope, z:1 = 0.01
Left Side Slope, z:1 = 0.01
Channel Slope = 0.01 ft/ft

Trapezoidal Channel

Assumed Depth (ft)	Calculated Depth (ft)	Average Velocity (ft/s)	Type of Flow	Froude Number	Cross- Sectional Area	Top Width	Hydraulic Radius
1.00	0.01						
0.50	0.01						
0.26	0.01						
0.13	0.02						
0.08	0.03						
0.05	0.04						
0.05	0.04						
0.04	0.04	0.46	SUBCRITICAL	0.3884	2.16	50.00	0.02
	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

RIP RAP CALCULATION USING: SAFETY FACTORS AND CORPS OF ENGINEERS METHODS

Pond 2 reclaimed 3.5h:1v outslope

WATER DEPTH=? (ft.)

0.02

RISE/RUN RADS DEGREES

0.286 0.279 15.96

BED SLOPE=? (RISE/RUN)

BANK SLOPE=? (RISE/RUN)

0.1 0.100 5.71

ANGLE OF REPOSE=? (DEGREES)

0.698 40.00

VEL. = ? 1.25 (fps)

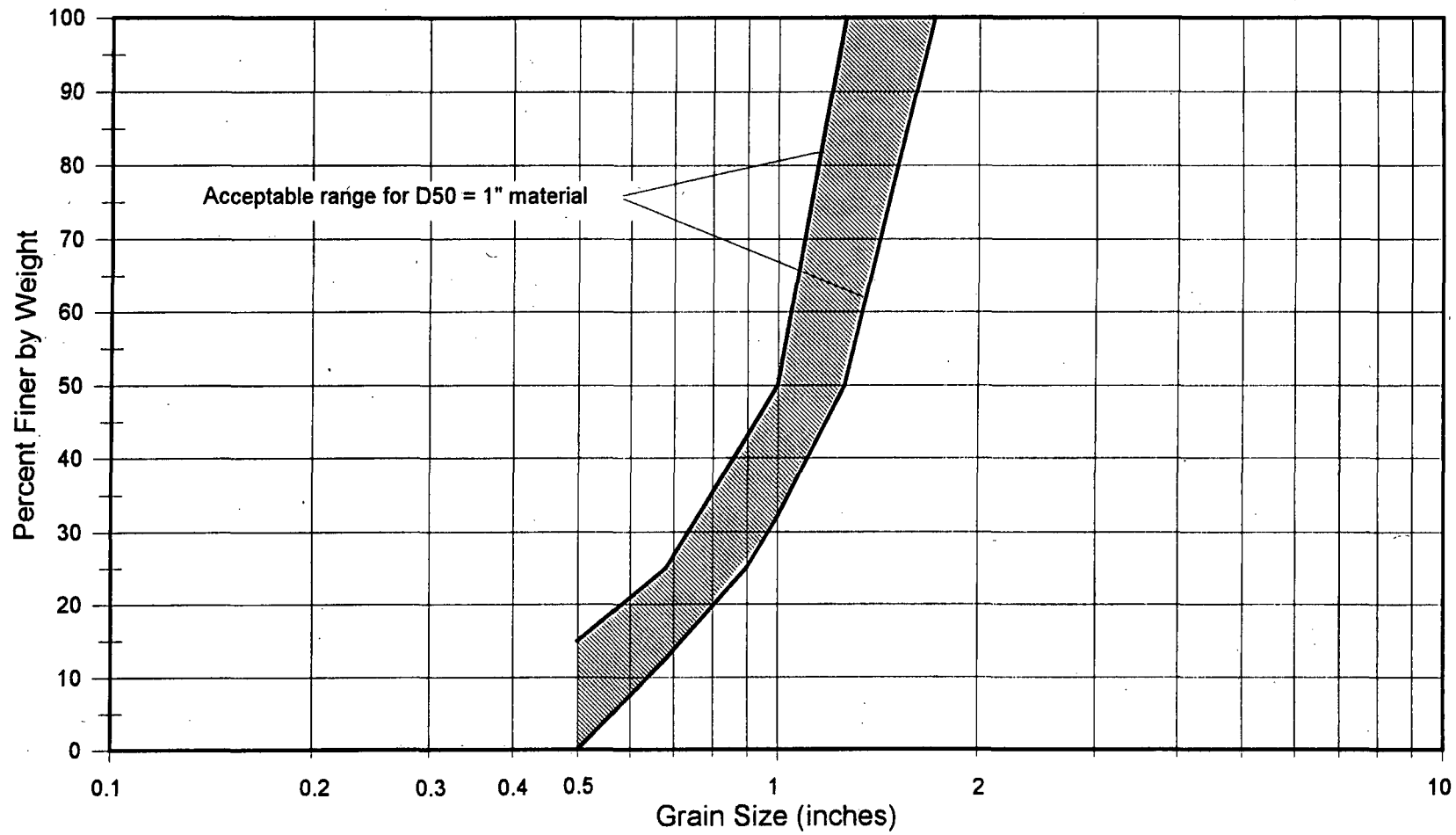
CORPS OF ENGINEERS METHOD

D-50 (ft)	DEPTH (ft)	T RACTIVE FORCE	N STABILITY PARAMETER	B (RADS)	B DEGREES	N'	SAFETY FACTOR	VEL. (fps)	T NEEDED TRACTIVE FORCE	T AVAILABLE	T SLOPE	SF
0.02	0.02	0.27	2.77	1.49	85.44	2.74	0.36	1.25	0.08	0.08	0.081	1.04
0.04	0.02	0.27	1.38	1.43	81.80	1.38	0.71	1.25	0.15	0.16	0.162	1.09
0.06	0.02	0.27	0.92	1.38	78.84	0.92	1.05	1.25	0.25	0.25	0.243	0.98
0.08	0.02	0.27	0.69	1.33	76.40	0.69	1.38	1.25	0.39	0.33	0.324	0.83
0.17	0.02	0.27	0.33	1.21	69.31	0.32	2.71	1.25	3.72	0.70	0.689	0.19
0.25	0.02	0.27	0.22	1.15	65.81	0.22	3.70	1.25	824.23	1.03	1.014	0.00
0.33	0.02	0.27	0.17	1.11	63.53	0.17	4.54	1.25	5.34	1.35	1.338	0.25

< 3/4"

Apex Site - Pond 2 Reclamation

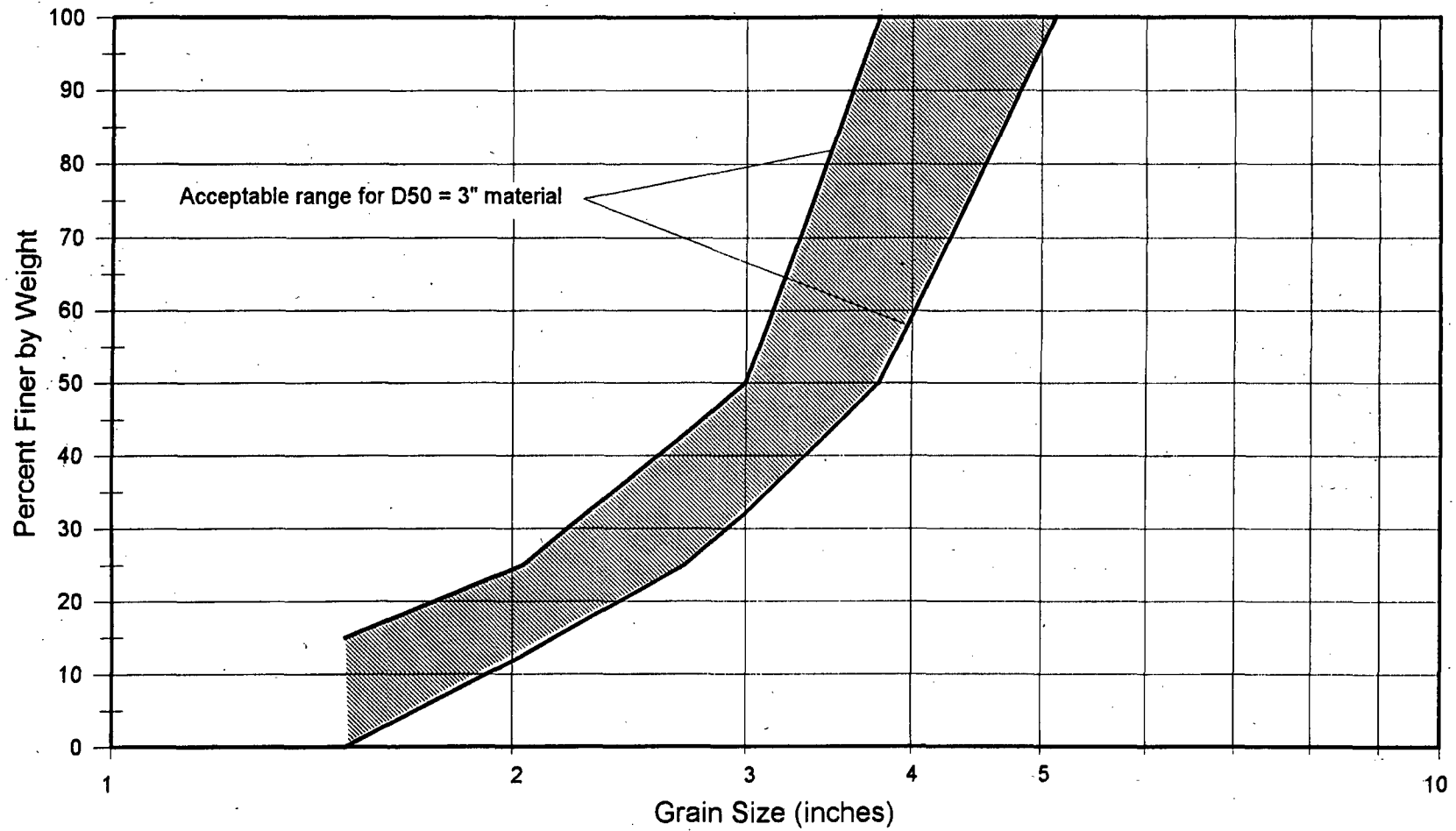
D50 = 1" Surface Layer Gradation



400175

Apex Site - Pond 2 Reclamation

D50 = 3" Erosion Protection Gradation



Appendix G
Cost Estimate

Appendix G - Cost Estimate

Summary

The estimated range of total construction costs to implement Hecla's Selected Alternative (GCL) as the Final Closure Plan at the Apex Site is \$341,670 to \$400,967. The estimated range of total construction costs to implement Hecla's Modified Alternative (Blue Clay) as the Final Closure Plan at the Apex Site is \$288,670 to \$366,667. Major cost items for the Selected Alternative are summarized in Table 1 on the following page. This table also contains details of quantities, unit prices, and delivery and placement costs. This estimated range is based on the assumption that all construction work will be conducted by outside contractors.

Unit prices for earthwork activities and materials were based on cost estimates provided by local and national vendors (NILEX 2003) (Kaul 2003), local material prices, and local equipment rates (L & M 2003) (Progressive 2003). Any unit prices required for this cost estimate that could not be based on actual bids were derived from the Caterpillar Performance Book (Caterpillar 1994), Estimating Excavation (Burch 1997), and construction experience.

Table 2 (second page following) contains a breakdown of estimated equipment type and hours required to complete each major work item. Table 3 contains equipment rates from the St. George area which were utilized in this cost estimate.

References

Burch 1997. D. Burch, Estimating Excavation, Craftsman Book Company, Carlsbad, CA.

Caterpillar 1994. Caterpillar Performance Book, Caterpillar, Inc., Peoria, Illinois.

Kaul 2003. Kaul Corporation, Lakewood, CO, *CETCO GCL Quotation, August 2003*.

L & M 2003. L & M General Engineering and Construction, Inc., St. George, UT, *Equipment Rental List, February 2003*.

NILEX 2003. NILEX Corporation, Englewood, CO, *Mebra Drain Vertical Wick Quotation, August 2003*.

Progressive 2003. Progressive Contracting Inc., St. George, UT, *Trucking Quotation, January 2003*.

Table 1
Cost Estimate - Selected Alternative (GCL)

Item #	Item	Quantity	Units	Purchase/ Excavation (\$/Unit)	Deliver (\$/Unit)	Place (\$/Unit)	Total (\$/Unit)	Estimated Cost Range	
								Low	High
1	Mobilization - Earthmoving Contractor	1	LS	\$2,000	NA	NA	\$2,000	\$2,000	\$2,400
	Phase I - Drainage & Consolidation								
2	Construct Exterior Containment Berm	1	LS	NA	\$0	\$300	\$300	\$300	\$450
3	Fabricate and Install Settlement Monuments	6	EA	\$50	\$0	\$200	\$250	\$1,500	\$1,800
4	Install Vertical Wick Drains @ 4 O.C.	200,000	LF	\$0.43	\$0.075	\$0.00	\$0.51	\$101,000	\$111,100
5	Construct Interior Containment Berms @ 30' O.C.	1	LS	NA	\$0	\$1,280	\$1,280	\$1,280	\$1,664
6	Remove & Dispose Evaporated Salts (top surface)	1	LS	NA	\$0	\$1,200	\$1,200	\$1,200	\$2,400
7	Remove & Dispose Evap Pond/Coll. Ditch Materials	1	LS	NA	\$0	\$1,500	\$1,500	\$1,500	\$2,250
	Phase II - Regrading								
8	Excavate Existing Embankment	9,300	CY	NA	\$0	\$0.56	\$0.56	\$5,250	\$7,875
9	Place Preloading on Top Surface	9,300	CY	NA	\$0	\$0.32	\$0.32	\$3,000	\$3,600
10	Final Grading of 1% Surface	9,300	CY	NA	\$0	\$0.24	\$0.24	\$2,250	\$3,150
	Phase III - Final Cover System Construction								
11	Mobilization - GCL Contractor / Installer	1	LS	\$2,500	\$0.00	\$0.00	\$2,500	\$2,500	\$3,000
12	Place Barrier Layer (GCL) - top	195,750	SF	\$0.25	\$0.05	\$0.10	\$0.40	\$78,000	\$85,800
13	Place Barrier Layer (GCL) - outslopes	49,500	SF	\$0.31	\$0.05	\$0.10	\$0.46	\$23,000	\$25,300
14	Strip & Grub Vegetation	1	LS	\$0.00	\$0.00	\$2,250	\$2,250	\$2,250	\$2,700
15	Excavate Diversion Channel	11,500	CY	\$0.65	\$0.26	\$0.00	\$0.91	\$10,500	\$12,600
16	Place Protection Layer (12" on-site materials)	8,000	CY	\$0.00	\$0.25	\$0.56	\$0.81	\$6,500	\$10,400
17	Reconstruct Outside Embankment	3,500	CY	\$0.00	\$0.29	\$1.81	\$2.10	\$7,350	\$11,025
18	Finish Grade 1% Surface - top	1	LS	\$0.00	\$0.00	\$2,250	\$2,250	\$2,250	\$4,500
19	Place Surface Layer (outslopes only) D50 = 1"	300	CY	\$7.00	\$4.00	\$5.00	\$16.00	\$4,800	\$5,760
20	Place Diversion Channel Erosion Protection (3" rock)	200	CY	\$7.00	\$4.20	\$7.75	\$18.95	\$3,790	\$4,548
21	Dust / Erosion Control	1	LS	\$2,700	NA	NA	\$2,700	\$2,700	\$2,970
22	QA / QC	60	Days	\$650	NA	NA	\$650	\$39,000	\$46,800
23	Construction Management	60	Days	\$500	NA	NA	\$500	\$30,000	\$33,000
24	Surveying (Settl. Mon., All Surfaces)	15	Days	\$800	NA	NA	\$800	\$12,000	\$18,000
							Totals	\$343,920	\$400,692

Table 2
Cost Estimate - Equipment Hours Breakdown

Item #	Item	Equipment Utilized, Hourly Rate, and Hours Required												Total Equip. Cost	Misc. Costs		Total Cost
		Ldr \$75	Exc \$125	Scr \$70	D5 DZR \$75	D7 DZR \$85	T.Trk \$75	S.D. Trk \$50	L.D. Trk \$60	Bld \$75	W.Trk \$45	Bkh \$50	Comp \$50				
1	Mobilization - Earthmoving Contractor						14							\$1,050	Trlr. Rent.	\$950	\$2,000
	Phase I - Drainage & Consol.																
2	Construct Exterior Containment Berm									4				\$300			\$300
3	Fab. / Inst. Settlement Monuments											24		\$1,200	Fabricate	\$300	\$1,500
4	Install Vertical Wick Drains @ 4 O.C.													\$0	Purch./Inst.	\$101,000	\$101,000
5	Constr. Int. Cont. Berms @ 30' O.C.					8				8				\$1,280			\$1,280
6	Remove & Dispose Evap. Salts	8								8				\$1,200			\$1,200
7	Rem. & Disp. Evap. Pond/Coll. Ditch		4					10				10		\$1,500			\$1,500
	Phase II - Regrading																
8	Excavate Existing Embankment		30					30						\$5,250			\$5,250
9	Place Preloading on Top Surface							30		20				\$3,000			\$3,000
10	Final Grading of 1% Surface									30				\$2,250			\$2,250
	Phase III - Fnl. Cover Sys.																
11	Mobilization - GCL Contr.													\$0	Mob.	\$2,500	\$2,500
12	Place Barrier Layer (GCL) - top													\$0	Install	\$78,000	\$78,000
13	Place Barrier Layer (GCL) - outslps													\$0	Install	\$23,000	\$23,000
14	Strip & Grub Vegetation		10					20						\$2,250			\$2,250
15	Excavate Diversion Channel		60					60						\$10,500			\$10,500
16	Place Protection Layer							40		60				\$6,500			\$6,500
17	Reconstruct Outside Embankment				10	10		20		50			20	\$7,350			\$7,350
18	Finish Grade 1% Surface - top									30				\$2,250			\$2,250
19	Place Surface Layer (outslopes only)				20				20					\$2,700	Purchase	\$2,100	\$4,800
20	Place Div. Ch. Eros. Prot. (3" rock)		10						14	4				\$2,390	Purchase	\$1,400	\$3,790
21	Dust / Erosion Control										60			\$2,700			\$2,700
22	QA / QC													\$0	QA / QC	\$39,000	\$39,000
23	Construction Management													\$0	CM	\$30,000	\$30,000
24	Surveying (Settl. Mon., All Surfaces)													\$0	Surveying	\$12,000	\$12,000
	Totals	8	104	0	30	18	14	190	34	214	60	34	20	\$53,670		\$290,250	\$343,920

Table 3 Estimated Equipment Rates ¹		
Equipment	Abbreviation	Hourly Rate ²
950 F Cat Loader	Ldr	\$75
325 Cat Excavator	Exc	\$125
Cat Scraper	Scr	\$70
Cat D5 Dozer Wide Track	D5 DZR	\$75
Cat D7 Dozer	D7 DZR	\$85
Transport Truck	T. Trk	\$75
Small Dump Truck	S.D. Trk	\$50
Large Dump Truck	L.D. Trk	\$60
Cat 12G Blade	Bld	\$75
Water Truck	W. Trk	\$45
JD Backhoe	Bkh	\$50
Self-propelled Sheep's Foot Compactor	Comp	\$50

1 - Approximate rates for St. George, Utah as of February 2003.

2 - All rates include operator.

Appendix H

Long-Term Monitoring and Maintenance Plan

Appendix H - Long-Term Monitoring and Maintenance Plan

Summary

This Long-Term Monitoring and Maintenance Plan details steps to be taken to ensure continued integrity and effectiveness of the Pond 2 final cover system at Hecla Mining Company's Apex Site. The key elements of the plan are:

- ▶ detection methods (monitoring schedule and site inspection methods)
- ▶ allowable limits (guidelines for interpreting monitoring results)
- ▶ remediation plan when/if limits are exceeded (list of preventative maintenance activities)

The plan contains the following items:

- ▶ monitoring schedule and site inspection methods
- ▶ guidelines for interpreting monitoring results
- ▶ list of preventative maintenance activities

Also included in this plan are a site inspection checklist and forms for the annual site inspections.

Monitoring Schedule and Site Inspection Methods

Site inspections will provide early warning of potential problems which could impact the final cover system's integrity. The Apex Site should be inspected annually to verify that the final cover system is functioning properly and to ensure that no significant problems are developing. The monitoring period may require adjustment based on data collected from the first inspection, as monitoring periods are a function of the stability of the waste and cover system.

Areas to be inspected annually include:

- ▶ Site Perimeter - site boundary and outlying areas up to 1/4 mile beyond Hecla's fence line. This includes the property fence, site entrance gate, and all upgradient drainage areas.
- ▶ Impoundment - top and outslopes, Protection Layer (top surface materials), and Surface Layer (erosion protection)
- ▶ Diversion Channel - erosion protection, normal flow channel, intersections with site perimeter fencing

The primary purpose of the annual inspection will be to look for evidence of significant movement of materials such as:

- ▶ cover subsidence
- ▶ excessive slope movement or failure
- ▶ gully development
- ▶ excessive siltation
- ▶ leachate migration

Guidelines for Interpreting Monitoring / Inspection Results

Table 1 on the following page contains details of how monitoring / inspection results should be interpreted, sets allowable limits, and provides an outline for repair activities required if allowable limits are exceeded.

Table 1
Problem Identification, Allowable Limits, and Repairs¹

Cover System Component	Problem	Allowable Limits	Repair if Allowable Limits are Exceeded
Cover System	Cover System Subsidence	ponding > 1" or gulying / erosion	<ul style="list-style-type: none"> ▶ backfill with additional cover material (TP-1, silty sand with gravel) to achieve lines and grades of original final cover surface ▶ minimize any flow concentration locations (potential pooling or erosion areas)
		see Table 2	<ul style="list-style-type: none"> ▶ remove Protection Layer and GCL in area of subsidence ▶ place light weight fill to achieve lines and grades of original subgrade ▶ replace / repair GCL ▶ replace Protection Layer
	Embankment Slope Instability	no signs of excessive embankment movement or surface cracks greater than 1"	<ul style="list-style-type: none"> ▶ remove erosion protection ▶ reconstruct embankment with additional embankment material (TP-1, silty sand with gravel) to achieve lines and grades of original embank surface (or flatter) and minimize any flow concentration locations (potential pooling or erosion areas) ▶ add toe berm along base of slope in failure area ▶ replace erosion protection
	gully development on impoundment top	depth > 1"	backfill to original grade with similar material type (TP-1, silty sand with gravel)
	gully development at embankment crest or on outslope	depth > 2"	backfill to original grade with similar material type ($D_{50} = 1"$ rock)
	gully development from normal flow channel in diversion channel parallel to and at toe of impoundment outslope	no gulying allowed	<ul style="list-style-type: none"> ▶ replace/repair any disturbed erosion protection (either $D_{50} = 1"$ or $D_{50} = 3"$ rock) ▶ backfill gully to original grade with native materials ▶ grade normal flow channel within diversion channel away from impoundment embankment
	gully development in diversion channel at any other location in diversion channel	NA	no repair required
Runoff Control System	seepage through embankment	no seepage allowed	<ul style="list-style-type: none"> ▶ remove embankment material in seepage area ▶ repair GCL liner and/or tie-in with original impoundment liner ▶ replace embankment material ▶ replace erosion protection
	excessive silt build up at fence lines in diversion channel	allowed if not effecting cover system	<ul style="list-style-type: none"> ▶ clear silt, organics, debris ▶ modify diversion channel alignment and/or gradients

¹ EPA 1988 - Guide to Technical Resources for the Design of Land Disposal Facilities

Cover System subsidence monitoring will be conducted by a visual inspection of the surface and a survey of the six installed settlement monuments. If the visual inspection, or settlement monument survey results, show that different areas of the cover are subsiding at substantially different rates (ponding greater than 1" and/or erosion and gulying), then a further and more detailed survey shall be conducted to delineate the area(s) of differential subsidence, and the amount(s) of maximum subsidence in each area. As noted in Table 1, there are separate repair methods for the two allowable subsidence limits listed. The first repair method is for "minor" differential subsidence, or that which will not potentially lower the permeability of the GCL. This method basically consists of adding Protection Layer material to achieve the original cover surface elevations and grades. The second repair method is for "significant" differential subsidence, or that which may lower the permeability of the GCL. If the calculated maximum differential settlement for a subsidence area is less than that shown in Table 2 below, then the first level of repair is adequate. If the calculated maximum differential settlement for a subsidence area is greater than that shown in Table 2, then the second level of repair will be required. Cumulative subsidence, and corresponding levels of repair, must be taken into account over time.

Table 2 Guidelines for Allowable Differential Settlement	
Radius of subsidence area (ft)	Maximum Differential Settlement (in each subsidence area) (ft)
1	0.2
2	0.4
5	1.0
10	2.0
25	5.0

Guidelines for maximum subsidence that GCL can withstand without damage (i.e., any lowering increase in permeability). (Daniel 1995)

Preventative Maintenance Activities

Preventative maintenance may be required for two to three years after completion of cover construction. As listed in Table 2 on the following page, maintenance activities in specific areas may include, but are not limited to the following activities:

- ▶ **minor differential subsidence** - place additional Protection Layer material to minimize flow concentration locations
- ▶ **large / potentially damaging differential subsidence** - remove Protection Layer and GCL, place light weight fill to achieve lines and grades of original subgrade, replace / repair GCL, replace Protection Layer
- ▶ **excessive movement or failure of impoundment embankments** - remove erosion protection, reconstruct embankment with additional material to achieve lines and grades of original

embankment surface and minimize any flow concentration locations, add toe berm along base of slope, replace erosion protection

- ▶ **excessive surface erosion (gullyng)** - place additional Protection Layer to achieve original lines and grades, place additional erosion protection or other materials as required
- ▶ **gullyng at toe of the impoundment within the diversion channel** - backfill gully to original grade with native materials, replace/repair disturbed erosion protection, grade normal flow channel within diversion channel away from impoundment embankment toe
- ▶ **excessive siltation** - clean / clear soil, organics, or other deleterious materials from diversion channel or fences, modify diversion channel alignment and/or gradients
- ▶ **leachate migration** - remove embankment material in seepage area, repair GCL liner and/or tie-in with original impoundment liner, replace embankment material, replace erosion protection

References

EPA 1988. *Guide to Technical Resources for the Design of Land Disposal Facilities*, Risk Reduction Engineering Laboratory, Cincinnati, OH, EPA/625/6-88/018.

EPA 1991. *Design and Construction of RCRA/CERCLA Final Covers*, Seminar Publication, Office of Research and Development, Cincinnati, OH, EPA/625/4-91/025

EPA 1998. *Evaluation of Subsurface Engineered Barriers at Waste Sites*, Office of Solid Waste and Emergency Response, EPA/542/R-98/005.

Long-Term Maintenance and Monitoring Plan

Annual Site Inspection Form 1 of 4

2003 - Apex Site - Pond 2 Reclamation

Date: _____		Inspector: _____	
Recent Weather: _____		Approximate Precipitation Amount: _____	
Site Perimeter (site boundary / outlying areas up to 1/4 mile away)			
Observed Condition:			
Observed Damage:			
Site Perimeter (property fence / gate)			
Observed Condition:			
Observed Damage:			
Corrective Actions Required:			
Site Perimeter (all upgradient areas)			
Observed Condition:			
Observed Damage:			

Long-Term Maintenance and Monitoring Plan

Annual Site Inspection Form 2 of 4

2003 - Apex Site - Pond 2 Reclamation

Date: _____		Inspector: _____	
Recent Weather: _____		Approximate Precipitation Amount: _____	
Impoundment (top and outslopes,)			
Observed Performance:			
Observed Damage:			
Corrective Actions Required:			
Impoundment (Protection Layer - top surface materials)			
Observed Performance:			
Amount and Location of Differential Subsidence:			
Observed Damage:			
Corrective Actions Required:			
Impoundment (Surface Layer - erosion protection)			
Observed Performance:			
Observed Damage:			
Corrective Actions Required:			

Long-Term Maintenance and Monitoring Plan

Annual Site Inspection Form 3 of 4

2003 - Apex Site - Pond 2 Reclamation

Date: _____ Inspector: _____	
Recent Weather: _____ Approximate Precipitation Amount: _____	
Diversion Channel	
Observed Performance:	
Observed Damage:	
Corrective Actions Required:	

Long-Term Maintenance and Monitoring Plan

Annual Site Inspection Form 4 of 4

2003 - Apex Site - Pond 2 Reclamation

Settlement Monument Survey Results			
Settlement Monument	Settlement This Period (inches)	Total Settlement (inches)	Location Requires Fill Material (Y/N)

Other Settlement Location Survey Results			
Settlement Location	Settlement This Period (inches)	Total Settlement (inches)	Location Requires Fill Material (Y/N)

Long-Term Maintenance and Monitoring Plan - Annual Site Inspection Checklist

2003 - Apex Site - Pond 2 Reclamation

Cover System Component	Potential Problem	Allowable Limits	Limits Exceeded (Y/N)
Cover System	Cover System Subsidence	Minor: ponding > 1" some gulying / erosion Significant: see Table 2	
	Embankment Slope Instability	excessive embankment movement or surface cracks > than 1"	
	gully development on impoundment top	depth > 1"	
	gully development at embankment crest or on outslope	depth > 2"	
	gully development from normal flow channel in diversion channel parallel to and at toe of impoundment outslope	no gulying allowed	
	gully development in diversion channel at any other location in diversion channel	NA	NA
	seepage through embankment	no seepage allowed	
Runoff Control System	excessive silt build up at fence lines in diversion channel	allowed if not effecting cover system	

Guidelines for Allowable Differential Settlement

Radius of Subsidence Area (ft)	Maximum Differential Settlement (in each subsidence area) (ft)
1	0.2
2	0.4
5	1.0
10	2.0
25	5.0

Guidelines for maximum subsidence that GCL can withstand without damage (i.e., any lowering increase in permeability). (Daniel 1995)

Appendix I
Construction Quality Control Plan

Appendix I - Construction Quality Control Plan

Summary

This Construction Quality Control Plan (CQCP) is for Hecla Mining Company's Pond 2 Final Closure Plan at the Apex Site near St. George, Utah. It presents how specific Construction Quality Control (CQC) activities will be applied during the project to ensure that construction meets the design intent. CQC activities will include direct monitoring, observation, testing, and control of the quality of final cover system construction at the site.

CQC refers to measures taken by the Contractor(s) / Installer(s) to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project. CQC will be performed by the General Contractor (GC), Earthwork Contractor (EC), and Geosynthetics Installation Contractor(s) (IC). Manufacturing Quality Control (MQC), which is direct monitoring and control during the manufacture of geosynthetic materials, will be performed by manufacturer(s). Each manufacturer's MQC data and information and CQC installation requirements will be provided by the IC's.

Responsibilities and Qualifications of Personnel

Responsibilities of key personnel will be identified prior to initiation of construction. Responsibilities of those personnel associated with the project are outlined in Table 1 at the end of this Appendix. Minimum recommended qualifications of each of the key personnel are listed in Table 2 at the end of this Appendix.

Background

The Apex Site is located approximately 15 miles northwest of St. George, Utah on land leased from the Shivwits Band of the Paiute Tribe. The Site can be accessed through the OMG facility on which it is located. The Site encompasses a total area of approximately 8 acres. Pond 2 (the impoundment) is a synthetically-lined waste containment facility which is roughly circular with an area of approximately 5 acres. The lining consists of a fabric-reinforced spray-on asphaltic membrane approximately one quarter (1/4) to one half (1/2) inch in thickness. Hecla removed and disposed a variety of on-site materials into Pond 2 including:

- ▶ gallium and germanium extraction process wastes (solutions and solids)
- ▶ cobalt-sulfate recovery process wastes
- ▶ ore stockpile materials
- ▶ old impoundment liner materials
- ▶ subsoils

Some of these materials were mixed with lime and limestone prior to disposal, while others were dredged and pumped into the impoundment as a slurry. During site cleanup work, the perimeter embankment

was raised approximately five feet (5') to provide sufficient capacity for material disposal. The embankment raise was constructed utilizing on-site soils (clay to cobble sizes) over the centerline of the existing embankment. The raise was unlined and the crest is approximately ten feet (10') wide. The embankment ranges from three feet (3') to seven feet (7') above the existing ground surface with outslopes that range from approximately 2:1 (H:V) to 3:1. Currently the impoundment has a temporary rock and topsoil cover which is approximately two (2') to four and one-half (4½') feet thick.

Project Objective

The general objective of the project is to construct a three-layered final cover system on Pond 2 (the impoundment) which will provide hydraulic isolation for wastes in the impoundment, and which will perform effectively over the long-term. Specifically, the work required to complete this project consists of the following activities:

- ▶ management of storm water, sediment and dust
- ▶ drainage and consolidation of waste materials currently within the impoundment
- ▶ burial of minimal amounts of additional on-site wastes (primarily geosynthetic liners and associated salts)
- ▶ removal of a portion of the existing impoundment embankment
- ▶ regrading the existing temporary cover and embankment materials after placement on the top surface
- ▶ rebuilding the impoundment embankment
- ▶ constructing the final cover system
- ▶ excavating a diversion channel around the reclaimed impoundment
- ▶ placing erosion protection

Construction Quality Control (CQC) Requirements

CQC verification activities (observations, inspections, and testing) are associated with both the earthen and geosynthetic materials to be installed and constructed. During construction each earthen and geosynthetic material component must be inspected to ensure that it has not been damaged during its installation or during construction of another component. Any damage that does occur must be repaired, and these corrective measures must be documented. Earthen materials CQC verification activities will include:

- ▶ screening incoming materials
- ▶ observing and testing constructed fills
- ▶ observing construction procedures
- ▶ measuring final cover layer thickness
- ▶ surveying final grades

CQC observations, inspections, and testing frequencies for the earthen materials are presented in Table 3 at the end of this Appendix.

Earthworks Specifications

Specifications for earthen materials used in each portion of the project are summarized in Table 4 at the end of this Appendix.

Geosynthetic CQC

Specific CQC activities associated with GCL construction and Wick Drain installation will be based on manufacturer's CQC manuals and installation requirements, and the project Specifications. These activities will include, but will not be limited to, measurement and observation of:

- ▶ manufactured thickness, width, and length
- ▶ protective covering
- ▶ marking and identification
- ▶ loading, shipment, and unloading
- ▶ site storage
- ▶ subgrade preparation
- ▶ deployment - manufacturer to provide site-specific panel layout plan
- ▶ low ground pressure deployment equipment
- ▶ verification of no damage to GCL that has been dragged during deployment
- ▶ protection from potential wind damage

Field Inspection Forms

Example CQC inspection and reporting forms which may be used during construction are attached. These forms allow for documentation of observations of typical construction activities including.

- ▶ Sediment Control Inspection
- ▶ Daily Work and Equipment Approval
- ▶ Daily Construction Activity / Inspection Report
- ▶ Daily Work Summary
- ▶ Daily Construction Summary Report
- ▶ Surveyor's Daily Time Log
- ▶ Erosion Protection Sieve Analysis
- ▶ Progress Review and Coordination Meeting (includes problem identification and corrective action)
- ▶ Drawings of Record (to be provided by CQC Surveyor)

The following CQC Inspection and Reporting forms will be provided by CQA Engineer and Installation Contractors, and approved by Owner's Representative prior to construction.

- ▶ Materials Test Reports (earthen materials)
- ▶ Geosynthetic (wick drain and GLC)

References

EPA 1987. *Construction Quality Assurance for Hazardous Waste Land Disposal Facilities*, Technical Guidance Document, Hazardous Waste Engineering Laboratory, Cincinnati, OH, EPA/530/(S)SW-86/031.

EPA 1988. *Guide to Technical Resources for the Design of Land Disposal Facilities*, Risk Reduction Engineering Laboratory, Cincinnati, OH, EPA/625/6-88/018.

EPA 1991. *Design and Construction of RCRA/CERCLA Final Covers*, Seminar Publication, Office of Research and Development, Cincinnati, OH, EPA/625/4-91/025

EPA 1993. *Quality Assurance and Quality Control for Waste Containment Facilities*, Technical Guidance Document, Risk Reduction Engineering Laboratory, Cincinnati, OH, EPA/600/R-93/182.

EPA 1998. *Evaluation of Subsurface Engineered Barriers at Waste Sites*, Office of Solid Waste and Emergency Response, EPA/542/R-98/005.

Table 1
Organization / Personnel Responsibilities

Organization/ Personnel	Responsibilities
USEPA	<ul style="list-style-type: none"> ▶ permitting agency ▶ reviews permit application / final cover system plan ▶ reviews all CQA documentation during and after construction to confirm CQA plan was followed and that cover system was constructed as specified
Owner	<ul style="list-style-type: none"> ▶ owns project ▶ designs, constructions, and maintains cover system ▶ complies with EPA requirements ▶ submits CQA documentation assuring EPA that cover system was constructed as specified
Owner's Representative	<ul style="list-style-type: none"> ▶ official representative of Owner ▶ coordinates schedules, meetings, and field activities ▶ communicates to Owner, EPA, material suppliers, GC, IC, EC and CQA Engineer
Design Engineer	<ul style="list-style-type: none"> ▶ designs cover system that fulfills operational requirements of Owner ▶ complies with accepted design practices that meet or exceed minimum requirements of EPA ▶ involved in CQA process
Manufacturers	<ul style="list-style-type: none"> ▶ manufactures geosynthetic clay liner (GCL) and Wick Drains
General Contractor (GC)	<ul style="list-style-type: none"> ▶ constructs overall cover system ▶ provides for CQC during construction ▶ purchases materials that meet specifications ▶ contracts with manufacturers of GCL and wick drains to supply material ▶ contracts with IC's ▶ controls overall construction operations, including scheduling and CQC ▶ primarily ensures that cover system is constructed according to specifications ▶ communicates with Owner and CQA Engineer regarding scheduling and occurrence of all construction activities
Installation Contractor (IC)	<ul style="list-style-type: none"> ▶ handles, stores, places, and installs GCL ▶ has CQC plan which details proper manner of handling, storage, placement, and installation of GCL and wick drains ▶ communicates with Owner and CQA Engineer regarding scheduling and occurrence of all GCL construction activities
Earthwork Contractor (EC)	<ul style="list-style-type: none"> ▶ grades site to elevations and grades shown on the plans and specifications ▶ constructs earthen components of cover system ▶ obtains suitable earthen materials ▶ transports, stores, pre-processes (if necessary), places, and compacts materials ▶ protects materials during and after placement ▶ carries out earthwork functions according to plans and specifications ▶ has CQC plan (or agree to one written by others) ▶ conducts CQC operations aimed at controlling materials and their placement so that they conform to the specifications ▶ communicates with Owner and CQA Engineer regarding scheduling and occurrence of all earthwork activities
CQC personnel	<ul style="list-style-type: none"> ▶ works for GC, IC and/or EC ▶ is thoroughly familiar with the specifications to ensure that materials and installation procedures conform to the contract standards ▶ makes construction crews aware of the relative "fragile" nature of the cover system components.

Table 1 Organization / Personnel Responsibilities	
CQA Engineer	<ul style="list-style-type: none">▶ oversees overall CQA inspections▶ reviews CQA plan, general plans, and specifications so that CQA can be implemented with no contradictions or unresolved discrepancies▶ educates CQA inspection personnel on CQA requirements and procedures, and special steps that are needed on the cover system project▶ schedules and coordinates CQA inspection activities▶ ensures that proper procedures are followed▶ ensures that testing laboratories conform to CQA requirements and procedures▶ confirms that test data are accurately reported and that test data are maintained for later reporting▶ prepares periodic reports▶ confirms that overall cover system was constructed in accordance with plans and specifications▶ notifies Owner of non-conformances▶ recommends work stoppages and possible remedial actions.
CQA personnel	<ul style="list-style-type: none">▶ makes observations and performs field tests to ensure that cover system is constructed in accordance with plans and specifications▶ reports to CQA Engineer

Table 2 Recommended Personnel Qualifications	
Individual	Minimum Recommended Qualifications
Design Engineer	Registered Professional Engineer
Owner's Representative	Specific individual designated by Owner with knowledge of the project, its plans, specifications, and CQC/CQA documents.
GCL Manufacturer	Experience in manufacturing at least 10,000,000 square feet of similar materials.
Wick Drain Manufacturer	Experience in manufacturing at least 10,000,000 linear feet of similar materials.
MQC Personnel	Manufacturer or trained personnel in charge of MQC of the GCL / wick drains to be used in the project.
MQC Officer(s)	Individuals specifically designated by the manufacturer(s) in charge of GCL / Wick Drain material MQC.
GCL / Wick Drain Installer's Representatives	Experience installing at least 10,000,000 square feet / 1,000,000 linear feet of similar GCL / Wick Drains, respectively.
CQC Personnel	<ul style="list-style-type: none"> ▶ employed by GC, IC, or EC ▶ qualified / certified in particular area of work being tested / observed
CQA Personnel	<ul style="list-style-type: none"> ▶ employed by an organization that operates separately from the GC and Owner ▶ qualified / certified in particular area of work being tested /observed
CQA Engineer	<ul style="list-style-type: none"> ▶ registered Professional Engineer employed by an organization that operates separately from the GC and Owner ▶ competent and experienced in similar projects ▶ hired by Owner ▶ functions separately from Contractors and Owner

Table 3				
CQC Observations, Inspections, and Testing Frequencies				
Material	Observation/ Inspection	Test	Minimum Test Frequency ²	
			Suggested Time Interval	cy/test
Borrow ¹				
General Fill Materials: Temporary Cover Materials Existing Embankment Materials General Earth Fill	Daily ³	Grain Size / Sieve Analysis (ASTM D422)	1 per day	4,000
		Standard Proctor (ASTM D698)	1 per day	4,000
Protection Layer Materials	Daily	Grain Size / Sieve Analysis (ASTM D422)	2 per day	2,000
		Standard Proctor (ASTM D698)	1 per day	4,000
		Atterberg Limits (ASTM D4318)	1 per day	4,000
		Moisture Content (ASTM D2216)	2 per day	2,000
Erosion Protection	Daily ⁴	Gradation (ASTM C136) Sieve Analysis (ASTM D422)	NA	100
Constructed Facility				
Vertical Wick Drains	Continuous	Observation ⁵	NA	NA
Regraded Temporary Cover (subgrade): Temporary Cover Materials Existing Embankment Materials General Earth Fill	Daily ⁶	In-place moisture / density (ASTM D1556)	2 per day	2,000
Embankment (General Earth Fill)	Daily	In-place moisture / density (ASTM D1556)	2 per day	1,000
Barrier Layer (GCL)	Continuous	Observation ⁵	NA	NA
Protection Layer (General Earth Fill)	Daily ³	In-place moisture / density (ASTM D1556)	2 per day	2,000
Surface Layer (Erosion Protection)	Continuous	Observation and Thickness	4 per day	50

Notes for Table 3 (following page):

1. Perform all tests when borrow material characteristics change, or 1 per day, whichever is greater.
2. Presented as a guide to CQC personnel. Testing frequency may be higher due to material availability. Similarly, the testing frequency of the index tests, i.e., Atterberg, Grain Size, and Gradation, may be decreased should material uniformity support a lower testing frequency. Specified time interval testing frequencies are for continuous construction activities, and should be modified accordingly for those tasks where construction is intermittent. The testing frequency of tests per cubic yard shall govern frequency.
3. Embankment excavation to be monitored continuously during excavation activities.
4. Erosion protection production facility to be observed once daily during production of rock.
5. Verification of material per Manufacturer's manufacturing quality control (MQC) plan for materials shipped to site, and verification of installation per Manufacturer's CQC requirements.
6. Final subgrade surface shall meet all requirements of GCL CQC plan.

Table 4
Earthworks Specifications Summary

Constructed Feature	Fill Type	Gradation		Maximum Loose Lifts	Moisture Content	Compaction
		Sieve Size	% Passing (by wt.)			
Temporary Cover	Temporary Cover	NA	NA	1 foot	NA	90% ASTM D698 or minimum 4 passes w/ smooth-drum, vibratory compactor ≥ 10 tons
	Existing Embankment	NA	NA	1 foot	NA	90% ASTM D698 or minimum 4 passes w/ smooth-drum, vibratory compactor ≥ 10 tons
	General Earth	4 inch	100	1 foot	NA	90% ASTM D698
Embankment	General Earth	4 inch	100	1 foot	NA	90% ASTM D698
Barrier Layer	GCL	NA	NA	NA	NA	NA
Protection Layer	General Earth	2 inch	100	1 foot ¹	NA	Use LGP ² Equipment 85% ASTM D698 ³
Surface Layer	Rock	D ₅₀ = 1"	NA	2" ⁴	NA	NA
Diversion Channel	Rock	D ₅₀ = 3"	NA	6" ⁴	NA	NA

Notes:

- 1 foot loose lift minimum thickness to protect GCL (Barrier Layer).
- LGP = Low Ground Pressure
- Maximum compaction of 85% ASTM D698 - no heavy equipment on Protection Layer until final grading being conducted
- Required layer thickness

Example CQC Inspection and Reporting Forms

Sediment Control Inspection Form

2003 - Apex Site - Pond 2 Reclamation

Date: _____		Inspector: _____	
Prec. Type & Amount: _____		Rainfall Duration: _____	
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			
AREA: _____			
Observed Performance:			
Observed Damage:			
Corrective Actions (if any):			

Contractor's Supervisor: _____ Construction Manager: _____

Daily Work and Equipment Approval

2003 - Apex Site - Pond 2 Reclamation

Report Number: _____		Date: _____	
Project: _____		Day: _____	
Work Project	Work to Be Addressed / Equipment to Be Used Today		
Surface Water Runoff Dust Control			
Settlement Monuments			
Vertical Wick Drains			
Temporary Containment Berms			
Evaporated Salts Collection Ditch Evaporation Ponds			
GCL			
Protection Layer			
Erosion Protection			
Miscellaneous / Other			

Contractor's Supervisor: _____ Construction Manager: _____

Daily Construction Activity / Inspection Report

2003 - Apex Site - Pond 2 Reclamation

[illegible]

Daily Work Summary

2003 - Apex Site - Pond 2 Reclamation

Report Number: _____

Date: _____

Project: _____

Day: _____

Equipment	Description / Operator	Hours Worked Today	Working Area
Dozers			
Scraper			
Loaders			
Excavator			
Grader			
Compactor			
Backhoe			
Truck			
Pickup			
Other			
Labor	Name	Hours	Working Area
Supervisor			
Grade Str.			

Material / Equipment	Hours Today	Hours Previous	Hours Total	Volume Today	Volume Previous	Volume Total

Contractor's Supervisor: _____

Construction Manager: _____

Daily Construction Summary Report

Day - , , 2004

Weather AM/PM

Contractor Work

•

•
•
•

•

•
•
•

Other Activities

Communications/Meetings:

•

•
•
•

•

•
•

•

•
•
•

Materials Testing:

Additional Issues

On-site Equipment:

Visitors:

Construction Manager, _____

2003 - Apex Site - Pond 2 Reclamation

Measured D_{100} (inches)	
Sample Median Diameter (D_{50}) (inches)	

$\frac{2.5 - D_{50}}{2.5 - 2.0} = \frac{\quad - \quad}{\quad - \quad}$	
$D_{50} = \underline{\hspace{2cm}}$	
$D_{25} = \underline{\hspace{2cm}}$	
$D_{15} = \underline{\hspace{2cm}}$	

Progress Review and Coordination Meeting

2003 - Apex Site - Pond 2 Reclamation

Meeting Date: _____

Location: _____

Attendees: _____

Work Schedule (see attached sheet)/quantities/status vs schedule)

Planned Work (equipment/manpower changes/potential conflicts or problems)

Specific Problems (lump sum work/hourly work/change order status)

Contract Items (work/bid clarifications/progress payments)

Safety

Contractor's Supervisor

Construction Manager

Apex Site
Final Engineering Report
for
Pond 2 Closure Plan
Volume II
Specifications and Drawings

Prepared for:

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Prepared by:

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March 25, 2004



VOLUME II

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- 3.0 Settlement Monuments
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- 5.0 Temporary Containment Berms
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1.0 Introduction

1.1 General

These Specifications are for the Final Closure Plan for Hecla Mining Company's Pond 2 at the Apex Site near St. George, Utah. The Work consists of all construction associated with implementation of the Closure Plan and completion of the closure of Pond 2. The Work is to be performed for Hecla Mining Company hereinafter referred to as the Owner. The Work is in general divided into three separate phases:

- ▶ Phase 1 - Waste Material Drainage and Consolidation
- ▶ Phase 2 - Impoundment Regrading
- ▶ Phase 3 - Final Cover System Construction

1.2 Background

The Apex Site is located approximately 15 miles northwest of St. George, Utah on land leased from the Shivwits Band of the Paiute Tribe. The Site can be accessed through the OMG facility on which it is located. A security fence surrounds the site.

The Apex Site encompasses a total area of approximately 8 acres. Pond 2 (the impoundment) is a synthetically-lined waste containment facility which is roughly circular with an area of approximately 5 acres. The lining consists of a fabric-reinforced spray-on asphaltic membrane approximately one quarter (1/4) to one half (1/2) inch in thickness. Hecla removed and disposed a variety of on-site materials into Pond 2 as part of a site cleanup in agreement with OMG in 1995. Materials currently in the impoundment include:

- ▶ gallium and germanium extraction process wastes (solutions and solids)
- ▶ cobalt-sulfate recovery process wastes
- ▶ ore stockpile materials
- ▶ old impoundment liner materials
- ▶ subsoils

Some of these materials were mixed with lime and limestone prior to disposal, while others were dredged and pumped into the impoundment as a slurry. During site cleanup Work, the perimeter embankment was raised approximately five feet (5') to provide sufficient capacity for material disposal. The embankment raise was constructed utilizing on-site soils (clay to cobble sizes) over the centerline of the existing embankment. The raise was unlined and the crest is approximately ten feet (10') wide. The embankment ranges from three feet (3') to seven feet (7') above the existing ground surface with outslopes that range from approximately 2:1 (H:V) to 3:1. Currently the impoundment has a temporary rock and topsoil cover which is approximately two (2') to four and one-half (4½') feet thick.

1.3 Description of Work

These Specifications address all Work at the Site. The Work is generally divided into the following activities:

- ▶ management of storm water, sediment and dust
- ▶ drainage and consolidation of waste materials within the impoundment
- ▶ burial of additional on-site wastes, removal of a portion of the existing embankment, regrading of temporary cover and embankment materials on the top surface
- ▶ rebuilding of the embankment and construction of the final cover system
- ▶ excavation of a diversion channel around the reclaimed impoundment and erosion protection placement

1.3.1 Storm Water Management, Sediment and Dust Control

Storm water and sediment management structures will consist of silt fences, straw bales, ditches, and containment berms. Silt fences and straw bales will be constructed at the downstream side of all excavation areas within the project boundary. Ditches and containment berms will be constructed to segregate runoff from the impoundment from that originating in undisturbed or other borrow areas. Locations of all structures will be subject to approval by the Owner's Rep.



All exposed and disturbed construction areas will be sprayed with water on a regular basis using a water truck. Construction roads and the borrow area will also be periodically sprayed with water to minimize dust production. Depending on climactic condition, all Work areas including borrow areas, haul roads, and general traffic areas will be sprayed with water at the end of each working day.

1.3.2 Waste Material Drainage and Consolidation (Phase 1)

Work to be completed in this phase consists of draining and evaporating free liquids within the waste materials. Settlement of the top surface of the impoundment will be measured with installed settlement monuments. Liquids emitting from the waste materials / wick drains will be managed with temporary fluid containment berms to maximize evaporation rates. Construction of the final cover system will begin when the Engineer has determined that overall settlement has slowed to an acceptable rate. Collection ditch and evaporation pond materials will be excavated and buried within the impoundment.

1.3.3 Impoundment Regrading (Phase 2)

Impoundment regrading will involve removal of a portion of the existing impoundment perimeter embankment. This material will be utilized as additional temporary cover material for the top surface and will assist with drainage and consolidation of the waste materials. Depending on the amount of fluids produced through the wick drains and the evaporation rate (fluid management and weather), this phase will most likely be incremental, with certain areas of the impoundment accessible sooner than others. The objective of the regrading is to achieve final impoundment configurations prior to Phase 3 (Final Cover System Construction).

1.3.4 Final Cover System Construction (Phase 3)

Final cover system construction will consist of placing the three separate material layers on the impoundment and reconstructing the impoundment embankment. The three layers consist of:

- ▶ a geosynthetic clay liner Barrier Layer (GCL)
- ▶ an on-site soils Protection Layer
- ▶ a rock erosion Surface Layer on the impoundment out slopes.

Protection Layer and embankment reconstruction soils will originate from the excavation / construction of the surface water diversion channel.

1.3.5 Surface Water Diversion Channel Construction

The diversion channel will be constructed as shown on the Drawings to the east of the reclaimed impoundment. Erosion protection will be placed at the west side of the diversion channel where it intersects the east side of the impoundment.

1.4 Definitions

The following definitions apply to these Specifications and Drawings:

- ▶ Owner - is an authorized representative of Hecla Mining Company
- ▶ Construction Quality Assurance Engineer (CQA Engineer) - qualified representative appointed and authorized by the Owner to monitor the quality of the completed construction product
- ▶ Engineer - authorized representative of the Owner who has designed the facilities to be constructed and prepared the Specifications and Drawings
- ▶ Owner's Representative - qualified Construction Manager or Engineer appointed and authorized by the Owner to provide third-party oversight during the construction process
- ▶ Contractor - the party or parties which have a contract agreement with the Owner and perform actual construction activities
- ▶ Specifications - this document of Technical Specifications prepared by Monster Engineering Inc., for the Apex Project, dated August 2003.
- ▶ Drawings - the drawings to be read in conjunction with these Specifications are titled, "Plans for Construction Apex Pond 2 - Final Reclamation"
- ▶ In-place material - soil or rock material existing within a particular construction area

- ▶ New Work areas - undisturbed areas or areas where clearing, grubbing, and or stripping has not previously been performed
- ▶ Borrowed material - material obtained from sources other than in-place that is transported to the construction areas
- ▶ All slopes are described in terms of horizontal distance:vertical distance.
- ▶ All sieve sizes refer to U.S. Standard sieve sizes.
- ▶ Where discrepancies between these Specifications, Drawings, scope of Work and bid documents occur, the more stringent interpretation or requirement will apply.

1.5 Submittals

1.5.1 Description

- A. The Contractor shall be responsible for submitting all submittals to the Engineer; checking submittals prior to submission to the Engineer; verification of field instruments, field construction criteria, catalogue numbers and similar data; and ensuring each item submitted clearly shows the Project Name and Title.
- B. Contractor's responsibility for errors and omissions in submittals is not relieved by the Engineer's review of submittals.
- C. The Contractor shall submit sufficiently early to provide adequate time for reviews, possible corrections and re-submittals, placing orders, securing delivery and to avoid construction delays.
- D. The Contractor shall accompany each submittal with a letter of transmittal containing all pertinent information required for identification and review of submittals. When submittals are resubmitted for any reason, transmit each re-submittal under a new letter or transmittal.
- E. Contractor shall not perform any part of the Work until the submittals for same have been reviewed by the Engineer.

1.5.2 Samples

- A. Before delivery of materials to the Site, the Contractor shall submit samples of materials as required by section of the Specifications and as requested by the Engineer. Contractor shall label samples as to origin and intended use in the Work and in accordance with the requirements of section of the Specifications. The Contractor shall ensure samples represent physical examples to illustrate materials, equipment or workmanship, and to establish criteria by which completed Work is judged.
- B. The Contractor shall ensure samples are of sufficient size and quantity, if not otherwise specified, to illustrate the quality and functional characteristics of product or material with integrally related parts and attachment devices, and color.
- C. The Contractor shall construct field samples and mock-ups on the Site at locations acceptable to the Engineer. Construct each sample or mock-up complete, including work of all trades required in finished Work.

1.5.3 Shop Drawings

- A. The term "shop drawings" means drawings, diagrams and other data which are provided by the Contractor to illustrate details of portions of the Work.
- B. The Contractor shall prepare shop drawings consistent with the Drawings in presentation, arrangement, and details where the latter are shown. Contractor shall prepare shop drawings in a manner which the Engineer considers necessary to show details of the Work to be performed. Contractor shall clearly identify each shop drawing by title and number of the Contract, and reference to applicable Contract Drawings.
- C. The Contractor shall ensure design information, calculations, and shop drawings required by Specifications or which are final drawings within the meaning of intent of applicable legislation relating to professional engineering in the jurisdiction in which project Site is located are sealed and signed by a registered professional engineer.
- D. The Contractor shall submit, in time to suit the Contract Schedule, not less than six (6) copies



- of shop drawings to the Engineer for Review. One (1) of the copies will be returned by the Engineer, stamped to indicate that the shop drawing has been reviewed and comments added where applicable. If shop drawings are illegible, obscure, or incomplete, they will be returned by the Engineer marked "not reviewed". Contractor shall redraw and resubmit shop drawings.
- E. The Contractor shall make corrections in shop drawings which the Engineer may require consistent with the Contract, and resubmit as before. When the Engineer's review is complete and requested corrections made, Contractor shall provide four (4) copies of certified drawings incorporating requested corrections, for the use of and distribution by the Engineer. Contractor shall ensure Work and units supplied conform to final drawings which must have the following notation:

Certified for Construction

Signature: _____

Date: _____

- F. The Contractor shall ensure the certification is signed by a Professional Engineer certified to carry out such practice in the State where the Work is to be performed.
- G. The Engineer's review of shop drawings is for the sole purpose of ascertaining conformance with the general arrangement, but no approval is given or responsibility assumed by the Engineer for the detail design inherent in the shop drawings or for corrections of dimensions or details or conformity to specification, which remain the responsibility of the Contractor submitting same.
- H. The Contractor shall supply drawings, templates, and special instructions as called for in the Specifications, and as required for the proper installation of the parts shown and in accordance with the intent of the Proposal Documents.

1.5.4 Product Data

- A. The term "product data" means schematic drawings, catalogue sheets, diagrams, illustrations, brochures, manufacturer's instructions and other data provided the manufacturer to illustrate details of a portion of the Work.
- B. The Contractor shall modify schematic drawings if and as necessary to ensure they show all and only the information applicable to the Work.
- C. On the catalogue sheets, diagrams, illustrations, brochures and other data, Contractor shall clearly mark each copy to identify materials, products or models applicable to the Work. Contractor shall show dimensions, clearances, performance characteristics, capacities, wiring diagrams and controls applicable to the Work.
- D. The Contractor shall submit four (4) copies of product data and manufacturer's instruction to Owner's Representative when required to supplement the Specifications for the assembly and installation of specific products.
- E. The Contractor shall provide copies of such approved data and instruction to each work crew working on the items affected.
- F. Product data and manufacturer's instructions only apply to particular requirements relative to the manufacturer's products and are in addition to the Specifications. Contractor shall not interpret or apply such instruction to limit the Work or responsibilities. The Proposal and Contract Documents take precedence in case of conflict. Contractor shall inform the Engineer promptly in writing in the event of such conflict.

1.5.5 Test Reports and Certificates

- A. The Contractor shall submit three (3) copies of each test report and each certificate to the Owner's Representative.
- B. The Contractor shall ensure each test report clearly shows:
1. Project Name
 2. Contract Number



3. Contract Title
4. Contractor's Name
5. Date of Test
6. Purpose of Test
7. Results of Test
8. Codes and Standards used for Test
9. Company or party making the Test
10. Company or party making the Report

1.5.6 Work Progress Schedule

- A. Scope: The Work specified in this subsection includes planning, scheduling, and reporting that is required to be performed by the Contractor.
- B. Method: A critical path or bar graph type schedule, fully man-loaded and prepared per each Contract item, shall be submitted with the Contract. Upon Owner review comments, the critical path schedule will be resubmitted to Owner within seven (7) calendar days after the effective date of the agreement.
- C. Schedule Requirements:
 1. Distinct items of contract works shall be defined and separated on the schedule. As a minimum, the work items shall include each contract pay item, mobilization, demobilization, and cleanup. Pay items that are partially subcontracted shall be split up to distinctly show the subcontracted work. These items of Work shall be plotted on a graph with calendar days duration as a horizontal reference. Anticipated start and finish dates for each Work stage and for each of the Work items within a stage, shall be shown.
 2. The project name, the Contractor's name, and the date of the submittal.
- D. Progress Reports:
 3. At the end of each week, the Contractor shall submit a summary report of the progress of the various scheduled Work items stating, for each item, the existing time status, estimated time of completion, and cause of delays, if any. If the Work is behind the previously submitted schedule, the Contractor shall submit an updated schedule and a written plan acceptable to the Owner for bringing the Work up to schedule.
 4. Updated schedules will be used by the Owner in compiling partial payments and no such computations will be made until the reports have been received and approved by the Owner.
 5. The Owner may request reports to be made on a more frequent schedule if he considers the substantial completion date to be in jeopardy because of activities behind schedule or for other valid reasons.

1.5.7 Certification of Tradesmen

The Contractor shall provide certificates to prove qualifications of personnel employed on the Work where such certification is required by authorities having jurisdiction, or by the Contract Documents.

1.5.8 Warranties

The Contractor shall submit warranties showing the project name and the contract number and title, warranty commencement data and duration of warranty. Contractor shall clearly indicate what the warranty covers and what remedial action shall be taken under the warranty. The Contractor shall ensure warranty bears the signature and seal of the Contractor.

1.5.9 Survey Data

The Contractor shall submit weekly to Owner a list of control points used for constructing the Work during that week. List of control points shall include mini-grid coordinates and elevations.

1.5.10 Geosynthetic Clay Liner Record Drawing

The GCL installation contractor shall provide scaled As-Built layout drawings on reproducible mylar



documenting the as-constructed panel and roll locations, at a suitable scale for presentation on 24-inch by 36-inch standard size drawings. The As-Built drawings are required to be drafted and of professional quality for approval by Engineer.

1.6 Quality Assurance

1.6.1 Description

This Section defines the project Quality Assurance requirement provided by the CQA Engineer. The CQA Engineer will be responsible for all quality assurance testing as outlined in this Specification and as indicated by the Owner, unless otherwise noted in the Specifications or the Drawings.

1.6.2 Construction Quality Assurance (CQA)

The CQA Engineer will maintain an effective CQA program. The CQA program will encompass all actions involving selection of construction material sources and on-site and off-site production of construction materials, work placement procedures, workmanship, monitoring, and testing.

1.6.3 CQA Testing and Frequency

CQA tests and frequency are discussed throughout the Specifications. The frequencies indicated are minimums only, and do not include retests of failed materials. Those CQA tests and testing frequencies to be conducted in the field by CQA Engineer are included in Table 1.1 and in the Specifications. Table 1.2 summarizes earthworks material specifications.

1.6.4 Quality of Materials and Labor

All materials used on this Contract shall be new and the best market quality, unless specified or shown otherwise. All labor on this contract shall be competent and skilled for the Work. All Work executed under this Contract shall be done in the best, most thorough, substantial and workmanlike manner. All material and labor shall be subject to the approval of the CQA Engineer as to quality and fitness, and shall be immediately removed if it does not meet with this approval. The Owner or the Owner's Representative may refuse to issue any certificate or payment until all defective materials or Work have been removed, and other material of proper quality substituted thereof.

1.6.5 Contractor's Responsibilities

- A. The Contractor is responsible for the quality of the Work of the Contract.
- B. The Contractor shall make good all Work for which any test result indicates the Work does not conform to the requirements of the Contract. Deem such Work to be condemned by the Engineer as in Article 9 of the General Conditions.
- C. The Contractor shall certify that all equipment used in the Work is in accordance with the provisions of the Contract. Certification does not relieve Contractor's responsibility for providing satisfactory materials, equipment, and workmanship.
- D. Any inspection and/or testing done for or on behalf of the Contractor shall not relieve the Contractor from any responsibility for the quality of the Work.
- E. The Contractor shall be aware of all CQA testing activities and shall account for those activities in the construction schedule.
- F. The Contractor shall be responsible for cooperating with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling, if requested, and shall also provide access to all areas requiring testing activities.

1.6.6 Inspection Schedule

- A. The regraded temporary cover surface shall be jointly inspected by design and construction engineers, and GCL installation Contractor, and approved before deployment of GCL will be permitted.
- B. Inspection of excavation of existing embankment materials will be continuous.
- C. Inspection of GCL materials during placement will be continuous.



Specification Table 1.1 CQA Testing Frequency			
Material	Test	Minimum Test Frequency ²	
		Suggested Time Interval	cy/test
1. Borrow ¹			
1.1 General Fill Materials: Temporary Cover Materials Existing Embankment Materials General Earth Fill	Grain Size	1 per day	4,000
	Compaction	1 per day	4,000
1.2 Protection Layer Materials	Grain Size	2 per day	2,000
	Compaction	1 per day	4,000
	Atterberg Limits	1 per day	4,000
	Moisture Content	2 per day	2,000
1.3 Erosion Protection	Gradation	NA	100
2. Constructed Facility			
2.1 Regraded Temporary Cover (subgrade): Temporary Cover Materials Existing Embankment Materials General Earth Fill	In-place moisture and density	2 per day	2,000
2.2 Embankment (General Earth Fill)	In-place moisture and density	2 per day	1,000
2.3 Barrier Layer (GCL)	visual observation	continuous	NA
2.4 Protection Layer (General Earth Fill)	In-place moisture and density	2 per day	2,000
2.5 Surface Layer (Erosion Protection)	visual observation	continuous	NA

Notes:

1. Perform all tests when borrow material characteristics change, or 1 per day, whichever is greater.
2. Presented as a guide to QC monitors. Testing frequency may be higher due to material availability. Similarly, the testing frequency of the index tests, i.e., Atterberg, Grain Size, and Gradation, may be decreased should material uniformity support a lower testing frequency. Specified time interval testing frequencies are for continuous construction activities, and should be modified accordingly for those tasks where construction is intermittent. The testing frequency of tests per cubic yard shall govern frequency.



Specification Table 1.2
Earthworks Specifications Summary

Constructed Feature	Fill Type	Gradation		Maximum Loose Lifts	Moisture Content	Compaction
		Sieve Size	% Passing (by wt.)			
Temporary Cover	Temporary Cover	NA	NA	1 foot	NA	90% ASTM D698 or minimum 4 passes w/ smooth-drum, vibratory compactor \geq 10 tons
	Existing Embankment	NA	NA	1 foot	NA	90% ASTM D698 or minimum 4 passes w/ smooth-drum, vibratory compactor \geq 10 tons
	General Earth	4 inch	100	1 foot	NA	90% ASTM D698
Embankment	General Earth	4 inch	100	1 foot	NA	90% ASTM D698
Barrier Layer	GCL	NA	NA	NA	NA	NA
Protection Layer	General Earth	2 inch	100	1 foot ¹	NA	Use LGP ² Equipment 85% ASTM D698 ³
Surface Layer	Rock	D ₅₀ = 1"	NA	2" ⁴	NA	NA
Diversion Channel	Rock	D ₅₀ = 3"	NA	6" ⁴	NA	NA

- Notes: 1. 1 foot loose lift minimum thickness to protect GCL (Barrier Layer).
2. LGP = Low Ground Pressure
3. Maximum compaction of 85% ASTM D698 - no heavy equipment on Protection Layer until final grading being conducted
4. Required layer thickness



2.0 General Excavation, Backfilling, and Compaction

2.1 General

2.1.1 Description

- A. This item shall include, but is not limited to, site preparation, clearing and grubbing, excavation, selective stockpiling of soils for earthwork related to excavation, rock and general fill placement, subgrade preparation for Geosynthetic Clay Liner (GCL), and anchor trench excavation.
- B. The Work includes furnishing all labor, tools, materials, equipment, and supervision as may be required to construct the Project as described in these Proposal and Contract Documents.

2.1.2 Related Work

- A. Section 3.0 Settlement Monuments
- B. Section 4.0 Vertical Wick Drains
- C. Section 5.0 Temporary Containment Berms
- D. Section 6.0 Evaporated Salts
- E. Section 7.0 Collection Ditch and Evaporation Ponds
- F. Section 8.0 Geosynthetic Clay Liner (GCL)
- G. Section 9.0 Protection Layer
- H. Section 10.0 Erosion Protection

2.1.3 References

American Society of Testing and Materials (ASTM) most current version:

- A. ASTM D422 - Method for Particle Size Analysis
- B. ASTM D1556 - Test Method for Density of Soil In-Place by the Sand Cone Method
- C. ASTM D698 - Test Methods for Moisture-Density Relationships of Soils and Aggregate Mixtures Using 5.5-lb hammer and 12-in. Drop
- D. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes
- E. ASTM D2922 - Test Methods for Density of Soils and Soil Aggregate in Place by Nuclear Methods (Shallow Depths)
- F. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- G. ASTM C136 - Rock gradations

2.1.4 Submittals

Contractor shall be responsible for submitting the following to the Owner's Representative:

- A. earthwork operations plan and schedule
- B. written plan of operation for the protection of the geosynthetic clay liner (GCL)
- C. sediment control plan

2.1.5 Tolerances

- A. Excavation limits are defined by the lines and elevations shown on the Drawings.
- B. All excavation operations shall be conducted in accordance with Idaho and Federal government laws and regulations
- C. Contractor shall maintain uniform gradients between adjacent spot elevations shown on the Drawings so that GCL can be deployed on a straight uniform grade without sags or humps.
- D. The tolerances for construction on all lines and grades, unless otherwise approved by the Engineer, shall be plus or minus 0.2 feet.
- E. When unfavorable conditions are discovered, they shall be corrected by excavation to lines, grades, depths, and dimensions prescribed by the Engineer.

2.1.6 Quality Assurance

- A. All Work shall be constructed, monitored, and tested in accordance with the requirements set forth by the Engineer.
- B. The Contractor shall be aware of all testing activities and they shall account for these activities

in the construction schedule.

- C. All soil testing (both field and laboratory testing) will be the responsibility of the CQA Engineer. The Contractor shall be responsible for cooperating with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling, if requested, and shall also provide access to all areas requiring testing.
- D. All excavation, backfill, and grading operations shall be carried out under the observation of the CQA Engineer.
- E. Any Work found unsatisfactory, or any Work disturbed by subsequent operations before acceptance is granted, shall be corrected by the Contractor as directed by the CQA Engineer.

2.1.7 Classification of Excavated Materials

Soils excavated shall be classified as follows:

- A. Common Excavation: This classification includes all material other than rock excavation.
- B. Rock Excavation: This classification includes all solid rock which cannot be removed until loosened by blasting, boring, or wedging. It is further defined as rock of such hardness and texture that it cannot be loosened or broken down by a single shank ripper mounted on a D8 Caterpillar bulldozer (or equivalent) in good operating condition handled by an experienced operator. In areas where it is impractical to classify material by use of the ripper method described, rock excavation is defined as sound material of such hardness that it cannot be excavated with a Caterpillar 225 backhoe (or equivalent) in good operating condition handled by an experienced operator. It also includes boulders and detached pieces of solid rock greater than three-quarters (3/4) of a cubic yard in volume.
- C. Classification: Soil excavated shall be classified as follows:
 - 1. Temporary Cover Material: This material shall consist of clay to cobble sized material existing on top of the impoundment at the beginning of the project
 - 2. Existing Embankment Material: This material shall consist of clay to cobble sized material existing in the current impoundment embankment at the beginning of the project.
 - 3. General Earth: General earth shall consist of the following two materials:
 - a. TP-1: Fine grained soil excavated from the upper layer of the Borrow Area / Diversion Channel excavation. This soil meets the requirements for the Cover System subgrade, Protection Layer, and Embankment Reconstruction. Only material classified as CL, ML, SC, or SM or any combination thereof, under the Unified Soil Classification System (ASTM D2487) will be used. Material will be free of roots, vegetation, or other deleterious materials.
 - b. TP-3: Fine grained soil excavated from the lower layer of the Borrow Area / Diversion Channel excavation. This soil meets the requirements for the Cover System subgrade and Embankment Reconstruction. Only material classified as CL, ML, SC, or SM or any combination thereof, under the Unified Soil Classification System (ASTM D2487) will be used. Material will be free of roots, vegetation, or other deleterious materials.
 - 4. Evaporated Salts: This material consists of potential evaporated salts remaining after completion of fluid evaporation on the top surface of the impoundment. Material sizes may range from clay to cobble sized particles.
- D. Selection and placement of classified soils into separate stockpiles shall be the responsibility of the Contractor. The Contractor shall familiarize himself with the materials classified above. The Engineer reserves the right to approve all material selection.

2.2 Products

2.2.1 Materials

- A. Materials used in conjunction with this Work shall be furnished by the Contractor, derived from the designated borrow area / excavations or off-site sources, and considered incidental to the Work items.
- B. Contractor shall use materials obtained from mandatory excavations / designated borrow areas which meet the applicable specifications. Such materials may be placed in the designated final

locations direct from the excavation.

- C. Contractor shall schedule excavation, placement, and compaction operations so as to avoid rehandling or stockpiling of excavated material.
- D. Fill materials will be on-site soils or off-site rock approved by the Engineer. The materials shall be free of organics or other deleterious materials, and shall be excavated, as required, as follows:
 1. Temporary Cover - on-site soils currently existing on the top surface of the impoundment (Temporary Cover), within the existing embankment (Existing Embankment), or in the Borrow Area / Diversion Channel excavation (General Earth). Materials currently on the impoundment surface shall be regraded to construct the temporary fluid containment berms. Materials from the existing embankment shall be utilized to increase temporary berm heights and as pre-loading on the top surface of the impoundment to speed drainage and consolidation of the wastes. After fluid evaporation is complete these materials shall be regraded and compacted, and prepared as the subgrade for the GCL. Materials from the Borrow Area / Diversion Channel excavation may be utilized to complete the 1% overall grade for the top surface of the impoundment.
 2. General Earth - on-site soil materials used to construct general grading fills, a subgrade surface for placement of the GCL in those areas where Temporary Cover materials are excessively rough or large, the Protection Layer directly above the GCL, and/or Embankment Reconstruction. General Earth fill materials can be any on-site material approved by the Engineer.
 3. Rock - materials used as the Surface Layer on the reconstructed embankment outslopes (2" layer of $D_{50} = 1"$ rock) and as erosion protection for the Diversion Channel (6" layer of $D_{50} = 3"$ rock). Rock materials shall consist of sound, hard, durable, inert, uncoated particles of rock or gravel, free from organic matter and other deleterious material, satisfying the requirements of Table 2.1 for erosion protection rock, or as approved by the Engineer.

Specification Table 2.1 Rock Material Specification		
	Material Type	
	Impoundment Embankment Surface Layer	Diversion Channel Erosion Protection
D_{50}	1 inch	3 inches
Minimum Layer Thickness	2 inches	6 inches

2.3 Execution

2.3.1 Clearing and Grubbing

Contractor is responsible for clearing and grubbing as follows:

- A. Clearing shall extend over all new Work areas to be excavated as delineated on the Drawings. Clearing shall extend a maximum of 15 feet and a minimum of 10 feet outside the construction limits or as directed by the Owner's Representative. Areas for clearing shall be released to Contractor by Owner's Representative.
- B. No clearing shall be performed until written permission is given by the Owner's Representative and until the Contractor has provided construction staking for the proposed Work.
- C. Clearing and grubbing shall consist of cutting brush and trees to ground level, and removing such material along with stumps, vegetation, roots one inch (1") in diameter or larger, wood, rubbish, and any other unsuitable fill materials. Vegetation, rubbish, and other unsuitable materials

removed during clearing and grubbing shall be removed from the cleared area and disposed of in an area designated, and in a manner approved by, the Owner's Representative.

- D. In no case shall unsuitable deleterious materials, as determined by the Engineer, be incorporated in the fill materials.

2.3.2 Excavation

Contractor is responsible for excavation as follows:

- A. Excavation shall be performed to the lines and grades shown on the Drawings or as directed by the Engineer. No excavation shall begin until the Contractor has provided construction staking for the proposed Work. All materials excavated shall be used as fill materials as determined by the classification of the material. During excavation, grades shall be maintained to provide drainage of any surface waters that may offset the Work.
- B. Contractor shall minimize the disturbance to surrounding areas during excavation. Where selective excavations are required to obtain materials for GCL subgrade fill, embankment fill, and/or Protection Layer, the material removed from the excavations shall be taken directly to the fill areas or, if required, stockpiled by material types. The stockpiles shall be located at Owner's Representative approved locations.
- C. Excavations shall be graded and properly maintained to provide adequate drainage at all times. Work shall be suspended by Contractor when, in the opinion of the Owner's Representative, the site is overly, wet, muddy, or otherwise unsuitable for proper maintenance, until directed otherwise by Owner's Representative.
- D. Where the required lines, levels, and grades are not otherwise defined (such as where Settlement Monuments are to be installed), excavate as necessary for items which are to be placed in the excavations, and as necessary to provide working space to install and inspect those items.
- E. All necessary precautions shall be taken to preserve the materials below and beyond the lines of excavation in the soundest possible condition. Where required to complete the Work, all excess excavation or over-excavation, shall be refilled with approved materials, placed and compacted to the satisfaction of the Owner's Representative.
- F. Safe temporary construction slopes shall be the responsibility of the Contractor. Contractor shall inspect all temporary and permanent open cut excavations on a regular basis for signs of instability. Should signs of instability be noted, Contractor shall undertake remedial measures immediately and shall notify Owner's Representative immediately. It shall be the Contractor's responsibility to remove all loose material from the excavation slopes and to maintain the slopes in a safe and stable condition at all times during the progress of the Work. Permanent cut slopes shall be left in smooth, safe, and stable condition at the end of the workday.
- G. Before excavating rock, submit the proposed method of excavation to the Owner's Representative for review. Ensure the method conforms to all applicable laws and regulations and to proven safe practices for the type of rock, proximity to structures and other installations, and other conditions; prevents opening of seams or otherwise disturbing or breaking the rock beyond the required lines, levels and grades; and keeps the danger and danger areas to the minimum practical. Mandatory use of approved blasting mats to restrain movement of material. Provide all flagman, signs, sirens, and other means necessary for safe use of explosives. Give all notices required by applicable regulations and safety requirements in addition to notices required by the Engineer. Before each blast, clear all personnel, vehicles, etc., from the blast area to safe limits and then ensure no personnel, vehicles, etc., enter the area until after completion of the blast. Scale the sides of rock cuts as soon as possible, preferably as the sides become exposed.

2.3.3 Surface Water Control

Contractor is responsible for surface water control as follows:

- A. Temporary and permanent surface water control features such as berms, basins, and channels will be constructed to the lines, grades, and slopes as approved by the Engineer and maintained during this Work.
- B. Contractor shall construct barriers, berms, dikes, or other measures as required to prevent significant erosion and sediment transport of excavation and fill areas from storm water runoff.



- C. The Contractor shall provide all equipment and facilities, and perform all Work to make and keep the Work areas dry of both surface and sub-surface water and to remove all sediments from all water before it leaves the Site; construct the temporary sediment control systems; improve the systems immediately if improvements are subsequently found to be necessary or prudent.
- D. The Contractor shall prevent injury and damage due to dewatering, disposal of water, and sediment control.
- E. The Contractor shall remove the temporary facilities when they are no longer necessary and restore the areas disturbed by dewatering and temporary sediment control.
- F. The Contractor shall be liable for injury and damage resulting from dewatering and for failure to satisfactorily dewater and control sediment.
- G. The Contractor shall be responsible for the construction of barriers, berms, dikes, or other measures required to control surface water runoff for the orderly progression of Work.

2.3.4 GCL Subgrade Preparation

Contractor is responsible for GCL subgrade preparation as follows:

- A. The GCL shall be placed on suitable subgrade which has been prepared by the Contractor. The subgrade shall be placed or excavated to the lines and grades shown on the Drawings, compacted to a minimum of 90 percent of maximum dry density as determined by the Standard Proctor test (ASTM D698) if General Earth fill is used, and with a minimum of four passes with a smooth-drummed vibratory compactor weighing no less than 10 tons if Temporary Cover or Existing Embankment materials are used.
- B. The subgrade for placement of the GCL shall contain no snow, ice, or frozen, saturated or other deleterious materials as determined by the CQA Engineer.
- C. The Contractor shall protect prepared subgrades from disturbance due to weather, surface water, construction equipment, or other factors. Subgrade surfaces, including previously approved subgrade, which become softened or otherwise unsuitable, shall be repaired to the CQA Engineer's satisfaction. Subgrades found to exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the Contractor to remove such defects.
- D. Sharp rocks or other deleterious debris, vegetation, roots, or sticks in the upper 4 inches of the final grade surface upon which the GCL is to be installed will be removed, with the final surface proof-rolled with a smooth drum drive vibratory compactor until it is smooth (no ridges, ruts, surface irregularities, etc.). Any remaining deleterious material including wheel ruts, that could potentially puncture the GCL, as determined by the GCL Installation Contractor or the CQA Engineer, shall be removed and repaired by the earthworks contractor. Subgrade surfaces to be lined with GCL shall be smooth and free of any as well as free of any voids, large cracks or standing water.
- E. The final grade shall be accepted in writing by the GCL Installation Contractor and approved by the Engineer prior to GCL installation.
- F. It shall be the GCL Installation Contractor's responsibility to indicate to the CQA Engineer any change in the subgrade condition that could cause it to be out of compliance with any of the requirements of this Section or the Specifications.

2.3.5 Fill and Compaction

Contractor is responsible for the following:

- A. Achieving the lines and grades as shown in the Drawings with fill materials.
- B. No GCL or fill materials shall be placed until the foundation and subgrade preparations have been completed as specified herein (Section 2.3.4). The procedures for fill placement shall be discussed with and approved by the Engineer prior to start of fill placement.
- C. No brush, roots, sod, or other deleterious or unsuitable materials shall be incorporated in the fills. The suitability of all materials intended for use in the fill shall be subject to approval by the CQA Engineer. Fill placement shall be temporarily stopped by the Contractor due to unsuitable weather conditions, or if materials and installation do not meet the Specifications. Fill shall not be placed upon frozen material unless approved by the CQA Engineer.
- D. If the surface of the prepared foundation or the rolled surface of any layer is excessively wet for



fill materials to be placed thereon, it shall be allowed to dry to reduce moisture content to an acceptable level as determined by the CQA Engineer. It shall then be compacted before the next layer of fill material is placed. Determination of such wet conditions shall be by the CQA Engineer.

- E. The distribution of material shall be such that the fill is free from voids, lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where gradations of two materials are not compatible, in the opinion of the CQA Engineer, the Contractor shall remove and replace the incompatible materials.
- F. Unless otherwise approved by the CQA Engineer, the fill surface shall be at or near the same elevation at all times during construction; maximum permissible difference between differing adjacent fills shall be one foot (1'). At all times during construction, the surface of the fill shall be graded to prevent ponding of water and maintained for storm water drainage.
- G. Except as otherwise specified or approved by the CQA Engineer, fill shall be dumped and spread in such a manner so that no excessive gaps are left between successively dumped loads of materials. The fill shall be leveled prior to compaction by means of a dozer or grader, or other suitable approved equipment, to obtain a surface free from depressions.
- H. Except in areas approved by the CQA Engineer where space is limited or otherwise specified, fill placement shall occur by routing the hauling and spreading units approximately parallel to the axis of the fill. As far as practical, hauling units shall be so routed that they do not follow in the same paths, but split their tracks evenly across the surface of the fill to enhance compaction.
- I. Water required for moisture conditioning shall be applied on the fill or in the borrow areas, with water trucks containing spray bars for even distribution of water. Fill materials shall be maintained at a moisture content near optimum to permit proper compaction to the specified density with the equipment being used. The moisture content of the fill materials, prior to and during compaction, shall be uniform throughout each layer of the material.
- J. After each layer of fill material has been placed, spread, and moisture-conditioned, the layer shall be compacted by passing compaction equipment over the entire surface of the layer a sufficient number of times to obtain the required density, as specified herein. Compacted lifts shall not exceed twelve inches (12").
- K. Compaction shall be accomplished with equipment and methods approved by the CQA Engineer. If such equipment or methods are found unsatisfactory for the intended use, the CQA Engineer shall require the Contractor to replace the unsatisfactory equipment with other types or to adjust methods until proper compaction is achieved.
- L. Where General Earth fill material contains large rocks or rock fragments, place and work the materials so that all solid pieces are well distributed and all interspaces are completely filled. Eliminate such solid pieces, over six inches (6") in their greatest dimension, from fill placed within twelve inches (12") of the surfaces of fill.
- M. Fill materials placed for the Embankment Reconstruction shall be compacted to a minimum of 90 percent of the maximum dry density as determined by the Standard Proctor (ASTM D698) compaction test. Fill materials placed for the Protection Layer shall be compacted to a maximum of 85 percent of the maximum dry density as determined by the Standard Proctor (ASTM D698) compaction test.
- N. General Earth fill materials with more than 30 percent rock particles in excess of three quarter inch (3/4") nominal size, which in the opinion of the CQA Engineer are not practical to be tested for moisture density control with ASTM D698 procedures, shall be placed and compacted according to a method specification. Method specifications shall be dependent upon the particular fill material's characteristics, the Contractor's equipment, and the field conditions, but at a minimum, will consist of fill placement in maximum one foot (1') loose lifts and uniformly compacted with a minimum of four passes. The Contractor shall be permitted to use alternative equipment, provided that the Contractor can demonstrate to the CQA Engineer that such alternative equipment shall compact the materials to a density not less than that which would be produced by the equipment specified. The method specifications may be changed at any time, at the discretion of the Engineer, based upon changes in material characteristics, field conditions, and/or equipment.
- O. Sharp or other deleterious objects in the outer four inches (4") of the final grade surface on the



embankment faces upon which the GCL will be installed, will be removed, with the final surface proof-rolled, with a minimum ten (10) ton, smooth drum drive, vibratory compactor, until it is smooth (no ridges, ruts, surface irregularities, etc.). Any remaining deleterious material including wheel ruts, that could potentially puncture the GCL, as determined by the GCL Installation Contractor or the CQA Engineer, shall be removed and repaired by the earthworks Contractor. The final grade surface shall be accepted in writing by the GCL Installation Contractor and approved by the CQA Engineer prior to GCL installation.

- P. The Contractor shall trim the outer face of the embankment using a dozer, or other suitable equipment, to the lines and grades shown on the Drawings. The final grade shall be approved by the CQA Engineer and Owner's Representative.

2.3.6 Field Quality Assurance

- A. The CQA Engineer will perform soil moisture, dry unit weight, and lift thickness tests in the field in accordance with requirements set forth by the Engineer.
- B. If the CQA Engineer tests indicate Work does not meet the requirements of the Specifications, the CQA Engineer will establish the extent of the nonconforming area. The nonconforming area shall be reworked by the Contractor at Contractor's expense until acceptable test results are obtained.
- C. The Contractor shall be aware of all field CQA testing activities, as these may affect the schedule, and shall comply with the requirements of Section 2.1.6 of this Specification.

2.3.7 Protection of Work

- A. The Contractor shall use all necessary means to protect all materials and all partially completed and completed Work of these Specifications.
- B. In the event of damage, the CQA Engineer will identify areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.
- C. At the end of each day, the Contractor shall verify that the entire work area was left in a state that promotes surface drainage off and away from the area and from finished Work. If threatening weather conditions are forecast, compacted surfaces shall be seal-rolled or covered with plastic sheeting to protect finished Work.

2.3.8 Survey Control

- A. Contractor's Surveyor shall perform pre-construction and post-construction surveys of the final regraded temporary cover surface immediately prior to GCL deployment, exposed existing impoundment liner and berm, reconstructed embankments, top of Protection and Surface Layers, and Diversion Channel areas prior to placement of fill materials and to determine quantities for payment purposes.
- B. Contractor's Surveyor shall provide Record Drawings of the locations and elevations of the impoundment facility including the GCL liner tie-in trench, final Diversion Channel configuration, Settlement Monument elevations, and top of both the Protection Layer and Surface Layer (erosion protection). Contractor's Surveyor shall submit these Drawings to the Owner's Representative.

3.0 Settlement Monuments

3.1 General

3.1.1 Description

- A. This Section describes the requirements for fabrication and installation of six (6) settlement monuments that will be placed on top of the impoundment prior to initiation of vertical wick drain installation.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

3.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 4.0 Vertical Wick Drains
- C. Section 5.0 Temporary Containment Berms
- D. Section 8.0 Geosynthetic Clay Liner (GCL)
- E. Section 9.0 Protection Layer

3.1.3 Tolerances

The Contractor is responsible for maintaining tolerances as follows:

- A. Contractor's Surveyor shall collect survey elevation data from each of the monuments on a regular (weekly) basis, or as required by the Engineer or Owner's Representative. Survey time intervals may increase or decrease depending on the amount of drainage and consolidation occurring.
- B. Contractor shall immediately notify Owner's Representative if, and when monuments are contacted, bumped, touched, or otherwise disturbed by any and all equipment, vehicles, or other objects such as, but not limited to, rocks or debris.
- C. Contractor's Surveyor shall re-survey any and all disturbed monuments within 24 hours of any such contact.
- D. Contractor's Surveyor shall re-survey all monuments after re-installation in the Protection Layer.

3.2 Products

3.2.1 Materials

- A. Each Settlement Monument shall consist of a minimum one inch (1") diameter, six foot (6') tall metal "stand pipe" welded to a metal base plate.
- B. Base plates shall be a minimum one-quarter inch (1/4") thick, and one foot (1') by one foot (1').
- C. All portions of the standpipe and base plate shall be painted fluorescent orange.
- D. Standpipe tops shall be flagged at all times after installation.
- E. Each monument will be "tagged" with an individual identification number, such as SM #1, SM#2, etc.

3.3 Execution

3.3.1 Placement

- A. Monument base plates will be buried at a depth of approximately one (1') to two (2') feet below the current temporary cover surface (for stability and protection). Stand pipes will extend approximately four (4') to five (5') feet above the ground surface after installation.
- B. Monuments will be removed prior to installation of the GCL.
- C. Monuments will be re-installed approximately six (6") to eight (8") inches into the Protection Layer after construction of the Protection Layer is completed.



3.3.2 Protection of Work

- A. Contractor shall use all means necessary to protect the monuments and to not contact, bump, touch, or otherwise disturbed any monument with any and all equipment, vehicles, or other objects such as, but not limited to, rocks or debris.
- B. Contractor shall immediately notify Owner's Representative if, and when monuments are contacted, bumped, touched, or otherwise disturbed by any and all equipment, vehicles, or other objects such as, but not limited to rocks or debris.
- C. In the event of any contact, the Owner's Representative will identify any monuments requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

3.3.3 Survey Control

The Contractor is responsible for survey control as follows:

- A. Contractor's Surveyor shall collect survey elevation data from each of the monuments on a regular (weekly) basis, or as required by the Engineer or Owner's Representative. Survey time intervals may increase or decrease depending on the amount of drainage and consolidation occurring.
- B. Contractor's Surveyor shall re-survey any and all disturbed monuments within 24 hours of any such contact.
- C. Contractor's Surveyor shall re-survey all monuments after re-installation in the Protection Layer.
- D. Contractor's Surveyor shall provide a Record Drawing to the Owner of the final location and top elevation of all monuments.



4.0 Vertical Wick Drains

4.1 General

4.1.1 Description

- A. This Section describes the requirements for installation of vertical wick drains at locations as directed by the Engineer.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

4.1.2 Related Work

- A. Section 4.0 Temporary Containment Berms
- B. Section 6.0 Evaporated Salts
- C. Section 8.0 Geosynthetic Clay Liner (GCL)

4.1.3 Submittals

The Contractor shall provide to the following information relating to the vertical wick drains manufacturer with its Proposal.

- A. Information from manufacturer including company name, address, telephone number, the names of the company president and manufacturing quality control manager, and narrative of the company history.
- B. Description of manufacturer's manufacturing capabilities:
 - 1. Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift.
 - 2. A list of standard material properties and test methods employed to arrive at the values for each. As a minimum, the list shall include properties given in Section 4.2.1.
- C. Contractor shall provide the following information after contract award, but within ten (10) days prior to materials arrival on-site and prior to commencement of the Work:
 - 1. Size, type, weight, maximum pushing force, and configuration of the installation rig
 - 2. Dimension and length of mandrel
 - 3. Details of drain anchorage
 - 4. Detailed description of proposed installation procedures
 - 5. Proposed methods for overcoming obstructions
 - 6. Proposed methods for splicing drains
 - 7. A copy of the manufacturer's QC test results of properties outlined in Part 4.2.1 of this Section. The Owner's Representative reserves the right to refuse use of any wick drain material without proper QC documentation.
 - 8. A detailed list of performance criteria for the wick drain material being produced for this Project.
- D. Contractor shall submit a one (1) meter sample of the drain materials to the Engineer / Owner's Representative prior to installation and shall allow three (3) weeks for evaluation of the material. The sample shall be stamped or labeled by the manufacturer as being representative of the drain material having the specified trade name. Approval of the material by the Engineer / Owner's Representative shall be required prior to delivery of the drain material.

4.1.4 Quality Assurance

- A. All Work shall be installed and monitored in compliance with requirements in the Construction Quality Assurance Plan (Section 1.6). Contractor and manufacturer shall participate and comply with all items in these Specifications and requirements of the CQA Plan.
- B. Contractor shall demonstrate that his equipment, methods, and materials produce a satisfactory installation in accordance with these Specifications. For this purpose, Contractor shall install several trial drains at locations within the Work area as designated

by the Engineer / Owner's Representative. Trial drains conforming to these Specifications will be paid for at the same unit price as the production drains.

- C. Contractor shall ensure that wick drain manufacturer has an internal product quality control program that meets Contract requirements.
- D. Contractor shall be aware of all activities outlined in the CQA Plan, and Contractor shall account for these activities in the construction schedule.
- E. Wick drain material that does not meet the requirements of this Specification will be rejected. Contractor will be required to replace the rejected material with new material that complies to the Specification, at no additional cost to Owner.

4.1.5 Delivery, Handling, and Storage

A. Packing and Shipping

- 1. Drain material shall be stamped or labeled by the manufacturer as being representative of the drain material having the specified trade name. Approval of the material by the QA Engineer / Owner's Representative shall be required prior to delivery of the drain material.
- 2. Contractor shall protect drain material from sunlight, mud, dirt, dust, debris, puncture, cutting, or other damage.
- 3. Contractor shall ensure that drain material is properly loaded and secured to prevent damage during transit.
- 4. Contractor shall ensure personnel responsible for loading, transport, and unloading are familiar with handling and transport constraints imposed by manufacturer.

B. Acceptance at Site:

- 1. Owner's Representative shall perform inventory and surface inspection for defects and damage of all drain material upon delivery.
- 2. Contractor shall inspect any drain material that may be damaged.
- 3. Contractor shall repair damage from handling and transport of drain material at no cost to Owner. If irreparable, in the opinion of the Owner's Representative, damaged materials shall be replaced at not cost to Owner.

C. Storage and Protection

- 1. Owner's Representative shall designate on-site storage area for drain material from time of delivery until installation.
- 2. Storage of drain materials is the responsibility of Contractor from the time materials are off-loaded until installation of materials is accepted. Contractor is responsible for preparing storage location and for protection of the materials from the elements (i.e., sunlight, dust, dirt, etc.)
- 3. Contractor shall preserve integrity and readability of drain material labels, and store such that Owner's Representative and CQA Engineer have access to the information to verify acceptance.

4.2 Products

4.2.1 Materials

- A. The prefabricated wick drain material shall consist of a continuous plastic (polypropylene) drainage core wrapped in a non-woven geotextile fabric of continuous filaments of 100% polypropylene similar to or equivalent of products known as Nilex Mebra-Drain or Ameridrain.
- B. The geotextile wrap shall be tight around the core and shall be seamed in a manner that will not all introduction of any new materials nor present an obstruction that will impede flow in the channels of the core.



4.3 Execution

4.3.1 Installation

- A. Drains shall be installed in the locations shown on the Drawings, or as directed by the Owner's Representative or Engineer.
- B. Drains that deviate from the plan location by more than six inches (6"), or that are damaged, or improperly installed will be rejected. Rejected drains will be abandoned in place.
- C. Replacement drains shall be offset approximately twenty inches (20") from the location of the rejected drain.
- D. Drains shall be installed vertically, within a tolerance of not more than 1:50 (H:V). Installation equipment shall be carefully checked for plumbness, and the Contractor shall provide the Owner's Representative with a suitable means of verifying the plumbness of the mandrel and of determining depth of drain at any time.
- E. Splices or connections in the drain material shall be completed in a professional manner that ensures continuity of the drain without diminishing the flow characteristics of the wick material.
- F. Splices shall be a minimum of six inches (6") in length. The drain shall be cut such that at least a six inch (6") length protrudes above the top of the ground surface at each drain location.
- G. If preaugering, or other methods, are required to clear obstructions and facilitate the installation of drains, then the depth of preaugering, or other method used, shall be subject to the approval of the Owner's Representative.
- H. Where obstructions are encountered within the compressible strata, which cannot be penetrated by augering, or other methods, the Contractor shall abandon the hole. At the direction of the Owner's Representative, Contractor shall then install a new drain within twenty inches (20") of the obstructed drain. A maximum of two attempts shall be made, as directed by the Owner's Representative, for each obstructed drain.
- I. Drains shall be installed to the depth of 13', or as specified by the Engineer.
- J. Drains shall be installed in such a manner as to not disturb settlement monuments already in place. The repair and/or replacement of monuments damaged as a result of the Contractor's activities shall be the responsibility of the Contractor.

5.0 Temporary Containment Berms

5.1 General

5.1.1 Description

- A. This Section describes the requirements for construction of the temporary containment berms which will contain fluids leaving the wastes via the vertical wick drains.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

5.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 3.0 Settlement Monuments
- C. Section 4.0 Vertical Wick Drains

5.1.3 Tolerances

Contractor is responsible for maintaining tolerances as follows:

- A. Temporary containment berms locations are shown on the Drawings.
- B. Maintain uniform berm heights as necessary to limit potential flow between berms.

5.2 Products

5.2.1 Materials

All temporary containment berms shall be constructed of temporary cover materials existing on the top surface of the impoundment. Additional materials from the existing embankment excavation or the Borrow Area / Diversion Channel Excavation may be used as necessary to contain fluids.

5.3 Execution

5.3.1 Construction

Contractor is responsible for construction of temporary fluid containment berms as follows:

- A. One perimeter berm will be constructed around the entire top surface of the impoundment at approximately twenty feet (20') in from the break between the top surface and the embankment outslope.
- B. Additional berms will be constructed on approximate thirty foot (30') centers from north to south and east to west as shown in the Drawings.
- C. Grade existing temporary cover material into perimeter and interior berms approximately one foot (1') in height and with spacing of approximately thirty feet (30'), or as directed by the Engineer or Owner's Representative.
- D. Perimeter berm will be constructed prior to initiation wick drain installation.
- E. Interior berms will be constructed immediately after installation of the Vertical Wick Drains, following the installation process to capture potential fluids exiting from the drains.
- F. Grading operations will be scheduled so as to not interfere with wick drain installation or operation of the installation equipment.

5.3.2 Protection of Work

- A. Contractor shall maintain the berms as needed for liquid retention, to prevent erosion of the embankment outsoles, and contain all liquids and solids on the top surface of the impoundment.
- B. In the event of any breach or damage to the berms, the Contractor shall immediately notify the Owner's Representative. The Contractor shall make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

6.0 Evaporated Salt Materials

6.1 General

6.1.1 Description

- A. This Section describes the requirements for removal and disposal of evaporated salts (if any) remaining after evaporation of liquids temporarily retained on top of the impoundment.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

6.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 8.0 Geosynthetic Clay Liner

6.1.3 Quality Assurance

All Work shall be constructed, monitored, and tested compliance with requirements in the Construction Quality Assurance Plan (Section 1.6).

6.2 Products

6.2.1 Materials

This material will consist of evaporated salts (if any) remaining after completion of fluid evaporation on the top surface of the impoundment.

6.3 Execution

6.3.1 Removal and Disposal

- A. Contractor shall excavate, combine, dispose of evaporated salts as directed by the Owner's Representative or Engineer.
- B. All evaporated salts (if any) shall be removed and disposed of prior to GCL deployment.

7.0 Collection Ditch and Evaporation Ponds

7.1 General

7.1.1 Description

- A. This Section describes the requirements for removal and disposal of Collection Ditch and Evaporation Pond materials currently located along the southwest embankment of the impoundment.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

7.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 8.0 Geosynthetic Clay Liner

7.1.3 Quality Assurance

All Work shall be constructed, monitored, and tested compliance with requirements in the Construction Quality Assurance Plan (Section 1.6).

7.2 Products

7.2.1 Materials

This material consists of all existing installed geosynthetic liner materials located along the southwest embankment of the impoundment, visible evaporated salts, and other materials associated with the Collection Ditch and Evaporation Ponds. Soils material sizes may range from clay to cobble sized particles.

7.3 Execution

7.3.1 Excavation and Disposal

- A. Contractor shall excavate, combine, compact, and bury all Collection Ditch and Evaporation Pond materials within the impoundment as directed by the Owner's Representative or Engineer.
- B. All Collection Ditch and Evaporation Pond materials shall be removed and disposed of prior to GCL deployment.

8.0 Geosynthetic Clay Liner (GCL)

8.1 General

8.1.1 Description

- A. This Section describes the requirements for manufacture, supply, and installation of the Geosynthetic Clay Liner (GCL) as shown in the Drawings; and construction quality assurance monitoring. All procedures, operations, and methods shall be in strict compliance with the Specifications, the Quality Assurance Plan, and the Drawings.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

8.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 6.0 Evaporated Salts
- C. Section 7.0 Collection Ditch and Evaporation Ponds
- D. Section 9.0 Protection Layer

8.1.3 Submittals

- A. The Contractor shall provide the following information relating to the GCL manufacturer.
 - 1. Information from manufacturer including company name, address, telephone number, the names of the company president and manufacturing quality control manager, and narrative of the company history.
 - 2. Description of manufacturer's manufacturing capabilities:
 - a. Information on plant size, equipment, personnel, number of shifts per day, and capacity per shift.
 - b. A list of standard material properties and test methods employed to arrive at the values for each. As a minimum, the list shall include properties given in Section 8.2.1.
 - 3. The Quality Control Manual followed during the manufacturing process including those for the clay and polymer materials, and a description of the quality control laboratory facilities, including the name and telephone number of the quality control manager. Upon review of the Quality Control Manual, the Owner's Representative and CQA Engineer may request additional testing during the manufacturing process at no additional cost to Owner. The Quality Control Manual shall become part of the Contract Documents following Owner's Representative and CQA Engineer's review and acceptance.
- B. Contractor shall provide the following information after contract award, but within ten (10) days prior to material arrival on-site and prior to commencement of the Work:
 - 1. The GCL manufacturer shall provide written certification that the GCL to be used meets the requirements of the Apex Project and that needle punched non-woven geotextiles have been continuously inspected for the presence of needles and geotextile was found to be needle free.
 - 2. A copy of the manufacturer's GCL QC test results of properties outlined in Section 8.2. The Owner's Representative reserves the right to refuse use of any GCL supplied without the proper QC documentation.
 - 3. A detailed list of performance criteria for the GCL material being produced for this project. Performance criteria refers to "minimum property values".

8.1.4 Quality Assurance

- A. All Work shall be constructed, monitored, and tested compliance with requirements in the Construction Quality Assurance Plan (Section 1.6). Contractor and manufacturer shall participate and comply with all items in these Specifications and requirements of the CQA plan.

- B. Contractor shall ensure that GCL manufacturer has an internal product quality control program that meets Contract requirements.
- C. Contractor shall be aware of all activities outlined in the CQA Plan, and Contractor shall account for these activities in the construction schedule.
- D. Contractor shall assure that the GCL is delivered to the site at least 14 calendar days prior to installation to allow sufficient time for conformance testing, if necessary.
- E. GCL material that does not meet the requirements of this Specification will be rejected. Contractor will be required to replace the rejected material with new material that complies to the Specification, at no additional cost to Owner.
- F. In order to prevent weather damaged GCL from being placed, the following procedures shall be followed:
 - 1. Contractor shall perform its Work and utilize sufficient ballast as necessary to prevent wind uplift of the GCL panels.
 - 2. If weather damage should occur, Owner's Representative and CQA Engineer shall determine if the GCL shall be repaired or replaced. Weather damage to the GCL will include hydrated bentonite, loss of bentonite, tears, dirty fabric, as determined by the Owner's Representative and CQA Engineer.
 - 3. Repair or replacement of the weather damaged GCL shall be completed by Contractor at no additional cost to Owner.
 - 4. As determined by Owner's Representative and CQA Engineer, the GCL panel may be rejected at no cost to Owner.

8.1.5 Delivery, Handling, and Storage

A. Packing and Shipping

- 1. GCL shall be supplied in rolls wrapped in relatively impermeable and opaque protective covers, with straps for unloading.
- 2. GCL rolls shall be marked or tagged with the following information:
 - a. Manufacturer's name
 - b. Product information
 - c. Roll number
 - d. Batch or lot number
 - e. Roll directions
- 3. Contractor shall ensure that GCL rolls are properly loaded and secured to prevent damage during transit.
- 4. Contractor shall protect GCL from excessive heat, cold, puncture, cutting, moisture, or other damaging or deleterious conditions.
- 5. Contractor shall ensure personnel responsible for loading, transport, and unloading are familiar with handling and transport constraints imposed by manufacturer.

B. Acceptance at Site:

- 1. Owner's Representative shall perform inventory and surface inspection for defects and damage of all drain GCL rolls upon delivery.
- 2. Contractor shall unroll and inspect any GCL roll that may be damaged below the surface.
- 3. Contractor shall repair damage from handling and transport of GCL at no cost to Owner. If irreparable, in the opinion of the Owner's Representative, damaged materials shall be replaced at no cost to Owner.

C. Storage and Protection

- 1. Owner's Representative shall designate on-site storage area for drain material from time of delivery until installation.
- 2. Storage of GCL is the responsibility of Contractor from the time materials are off-loaded until installation of materials is accepted. Contractor is responsible for preparing storage location and for protection of the materials from the elements (i.e., sunlight, dust, dirt, etc.)
- 3. After Contractor has removed material from the storage area, protect GCL from puncture, dirt, groundwater, fluids, moisture, mud, mechanical abrasion, excessive heat,



ultraviolet light exposure, and other sources of potential damage.

4. GCL rolls shall be stored in relatively opaque and water tight wrappings.
5. Contractor shall preserve integrity and readability of GCL roll labels, and store such that Owner's Representative and CQA Engineer have access to the information to verify acceptance.

8.2 Products

8.2.1 Materials

- A. The GCL shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all criteria listed in this Section.
- B. Reinforced GCL must be used on embankment out slopes as designated by the Engineer. Unreinforced GCL may be used on slopes not exceeding 10:1 (H:V).
- C. Acceptable unreinforced GCL products are Claymax 200R, or an Engineer approved equivalent. Acceptable reinforced GCL products are Bentomat DN, or an Engineer approved equivalent.
- D. Delineation of areas requiring reinforced GCL will be agreed upon by the GCL Installation Contractor and the Owner's Representative / CQA Engineer prior to installation.
- E. GCL properties shall meet or exceed the minimum values shown in Table 8.1 below:

Specification Table 8.1 Minimum Values for GCL		
Property	Test Method	Value
Values for GCL Material		
Bentonite Swell Index	ASTM D5890	24 ml/2 g min
Bentonite Fluid Loss	ASTM D5891	18 ml max.
Bentonite Mass/Area	ASTM D5993	0.75 lb/ft ²
Values for Reinforced GCL Material		
GCL Grab Strength	ASTM D4632	150 lbs MARV
GCL Peel Strength	ASTM D4632	15 lbs min.
GCL Permeability	ASTM D5887	5 x 10 ⁻⁹ cm/sec max.
Geotextile Mass/Unit Area	ASTM D5261	3.0 oz/yd ²
GCL Hydrated Internal Shear Strength	ASTM D5321	500 lbs/ft ²
Values for Unreinforced GCL Material		
GCL Grab Strength	ASTM D4632	100 lbs MARV
GCL Permeability	ASTM D5887	5 x 10 ⁻⁹ cm/sec max.
Geotextile Mass/Unit Area	ASTM D5261	3.0 oz/yd ²
GCL Hydrated Internal Shear Strength	ASTM D5321	50 lbs/ft ²

8.3 Execution

8.3.1 Installation

A. GCL deployment shall not begin until Contractor's Surveyor has verified that subgrade elevations and grades conform to the Drawings and until the CQA Engineer documents that the Contractor's Work is in conformance with the Proposal Documents.

B. GCL Deployment

Contractor shall handle GCL in a manner to ensure that GCL is not damaged, and shall comply with the following:

1. Installation Contractor and Owner's Representative shall review and agree upon which type of GCL (Reinforced and Unreinforced) shall be placed in which areas prior to installation.
2. GCL shall be delivered to the Work area on the Site in the original packaging. Immediately prior to deployment, packaging shall be carefully removed without damaging the GCL. The GCL shall be oriented (which side faces up) in accordance with the Engineer's recommendation.
3. No equipment or tools shall damage the GCL by handling, trafficking, or other means.
4. No personnel working on the GCL shall smoke, wear damaging shoes, or engage in other activities that could damage the GCL.
5. Dragging the GCL across the subgrade shall be minimized, and if dragging is necessary, a slip sheet shall be used to reduce friction damage.
6. GCL shall not be deployed during precipitation events; in the presence of excessive moisture, (e.g., fog, dew, frost, rain, snow, sleet, hail), in an area of ponded fluids, or in the presence of excessive winds.
7. GCL shall not be deployed over frozen ground, unless approved by Owner's Representative and CQA Engineer.
8. In the presence of wind, all GCL shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover materials.
9. GCL panels shall be deployed in such a manner as to preclude wrinkles and folds.
10. GCL panels shall be deployed parallel to the direction of the slope.
11. GCL shall be cut with a cutter approved by Owner's Representative and CQA Engineer, such as scissors. Unshielded razor knives are not acceptable.
12. During deployment care shall be taken to not entrap in or beneath the GCL, stones, excessive dust, or moisture that could potentially damage the GCL or hamper subsequent seaming or overlap.
13. Following installation of all GCL, and prior to placing covering material, an examination of the entire surface shall be conducted to detect potentially harmful foreign objects. Any such foreign objects found shall be removed or the panel shall be replaced by the Contractor, at no cost to Owner.
14. GCL that is hydrated before placement of overlying cover material shall be replaced.
15. Only deploy GCL that can be covered during that day by a minimum of twelve inches (12") of approved cover soil.

C. Anchorage

1. Contractor shall place in an anchor trench the end of the GCL roll as directed in the Drawings.
2. The front edge of the trench shall be rounded so as to eliminate any sharp corners.

D. Seaming

1. Panels shall be overlapped a minimum of six inches (6").
2. The overlap zone shall be kept free of soil or other debris.
3. A continuous bead of supplemental bentonite shall be applied in the overlap zones at the rate required by the manufacturer (typically one quarter (1/4) pound per lineal foot).
4. Seams at the end of panels shall be constructed such that they are shingled in the



direction of the grade to prevent the potential for runoff flow entering the overlap zone.

E. Defects and Repairs

Contractor shall repair holes or tears in the GCL as follows:

1. Remove all soil or other material that may have penetrated the torn GCL.
2. Repair all flows or damage areas by placing a patch of the same GCL material extending a minimum of twelve inches (12") overlap in all directions. Apply granular bentonite between the GCL layers in the overlap area at rate required by the manufacturer.

8.3.2 Placement of Cover Soils

Contractor shall place all soil materials to be located on top of the GCL in such a manner as to ensure:

- A. The GCL is not damaged.
- B. Minimal slippage of the GCL on the underlying layers occurs.
- C. No excess tensile stresses shall occur in the GCL, such as by earthmoving equipment making sudden stops, starts, or turns. Only low ground pressure (LGP) equipment, approved by the Owner's Representative and Engineer, for the material type and layer thickness, shall be used by the Contractor.
- D. A minimum thickness of one foot (1') of cover shall be maintained between the equipment tires/tracks and the GCL at all times during the covering process.
- E. Soil cover shall be placed in a manner that prevents soil from entering the GCL overlap zones.
- F. Cover soil shall be pushed up slopes and not down to minimize tensile forces on the GCL.

9.0 Protection Layer

9.1 General

9.1.1 Description

- A. This Section describes the requirements for construction of the Protection Layer on top of the GCL, and rebuilding of the exterior impoundment embankments.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

9.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 3.0 Settlement Monuments
- C. Section 8.0 Geosynthetic Clay Liner
- D. Section 10.0 Erosion Protection

9.1.3 References

American Society for Testing and Materials (ASTM) most current version:

- A. ASTM D422 - Method for Particle Size Analysis
- B. ASTM D1556 - Test Method for Density of Soil In-Place by the Sand Cone Method
- C. ASTM D698 - Test Methods for Moisture-Density Relationships of Soils and Aggregate Mixtures Using 5.5-lb hammer and 12-in. Drop
- D. ASTM D2487 - Standard Test Method for Classification of Soils for Engineering Purposes
- E. ASTM D2922 - Test Methods for Density of Soils and Soil Aggregate in Place by Nuclear Methods (Shallow Depths)
- F. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

9.1.4 Submittals

Contractor shall submit a plan and schedule for delivery and placement of the Protection Layer soils, including a description of the equipment and procedures to be used and methods for placement. This plan and schedule shall be approved by the Owner's Representative and Engineer prior to the start of Protection Layer placement.

9.1.5 Tolerances

Contractor is responsible for maintaining tolerances as follows:

- A. Placement limits are defined by the lines and elevations shown on the Drawings, and shall be a minimum of one foot (1').
- B. Maintain uniform gradients between adjacent spot elevations, without sags or humps.
- C. Finish grade top of Protection Layer surface to within +0.0 to +0.2 feet of lines and elevations shown on the drawings.

9.1.6 Quality Assurance

- A. Contractor shall place Surface Protection materials in accordance with these Specifications and industry construction practices acceptable to the CQA Engineer.
- B. The Contractor shall be aware of all CQA activities and shall account for these activities in the construction schedule.
- C. All soil testing (both field and laboratory testing) will be the responsibility of the CQA Engineer. The Contractor shall be responsible for cooperating with the CQA Engineer during all testing activities. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling, if requested, and shall provide access to all areas requiring testing.
- D. Contractor shall be responsible for replacing Protection Layer material not meeting the Specifications as determined by field testing.
- E. Any Work found unsatisfactory or any Work disturbed by subsequent operations before

acceptance is granted shall be corrected by the Contractor as directed by the CQA Engineer.

9.2 Products

9.2.1 Materials

- A. Protection Layer soils shall be prepared by the Contractor and tested by the CQA Engineer.
- B. Protection Layer soils shall be free of roots, woody vegetation, particles greater than two inches (2") in diameter, and other deleterious material.
- C. Protection Layer shall not be compacted to greater than 85% of maximum density as determined by ASTM D698.

9.3 Execution

9.3.1 Placement

- A. Protection Layer placement shall begin only after acceptance of GCL materials.
- B. The Contractor shall construct the Protection Layer in one (1) lift not to be less than one foot (1') in thickness at all times.
- C. A minimum thickness of one foot (1') of Protection Layer soils shall be maintained between the equipment tires/tracks and the GCL at all times during the covering process.
- D. Protection Layer soils shall be placed in a manner that prevents soil from entering the GCL overlap zones.
- E. Protection Layer soils shall be pushed up slopes and not down to minimize tensile forces on the GCL.

9.3.2 Field Quality Assurance

- A. The CQA Engineer will perform soil moisture, dry unit weight, and lift thickness tests in the field on the Protection Layer soil to determine compliance with this Specification. Testing will be carried out in accordance with the requirements set forth by the Engineer.
- B. If the CQA Engineer's test results indicate Work does not meet the requirements of the Specifications, the CQA Engineer will establish the extent of nonconforming area. The nonconforming area shall be reworked or replaced by the Contractor, at their expense, until acceptable test results are obtained.
- C. The Contractor shall be aware of all field quality assurance testing activities, as these may affect their schedule, and they shall comply with the requirements of these Specifications.

9.3.3 Protection of Work

- A. After Protection Layer soils have been placed, the Contractor shall maintain it free of ruts, depressions, and damage resulting from the hauling and handling of any material, equipment, tools, etc.
- B. The Contractor shall use all means necessary to protect all materials and all partially completed and completed Work of these Specifications.
- C. In the event of damage, the CQA Engineer will identify any areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

9.3.4 Survey Control

- A. Contractor's surveyor shall survey the final location and elevation of the top of the Protection Layer to determine quantities for payment.
- B. Contractor's Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top of the Protection Layer.

10.0 Erosion Protection

10.1 General

10.1.1 Description

- A. This Section describes the requirements for placement of erosion protection along the outsoles of the impoundment, and at the edge of the Diversion Channel where it intersects the toe of the impoundment.
- B. The Work includes furnishing all labor, tools, equipment, and supervision as may be required to construct the Work as described in the Proposal and Contract Documents.

10.1.2 Related Work

- A. Section 2.0 General Excavation, Backfilling, and Compaction
- B. Section 9.0 Protection Layer

10.1.3 References

American Society for Testing and Materials (ASTM) most current version:

- A. ASTM C136 - Rock Gradations

10.1.4 Submittals

Contractor shall submit erosion material samples prior to delivery for testing by CQA Engineer in accordance with the Specifications.

10.1.5 Tolerances

Contractor is responsible for maintaining tolerances as follows:

- A. Placement limits are defined by the lines and elevations shown on the Drawings.
- B. Maintain uniform gradients between adjacent spot elevations on the Drawings, without sags or humps.
- C. Place erosion protection material within +0.0 to +0.2 feet of the lines and elevations shown on the drawings.

10.1.6 Quality Assurance

- A. All Work shall be placed, monitored, and tested in accordance with the requirements set forth by the Engineer.
- B. The Contractor shall be aware of all CQA activities and shall account for these activities in the construction schedule.
- C. On-site conformance testing and field quality assurance testing of granular materials will be the responsibility of the CQA Engineer. The CQA Engineer will obtain conformance samples of the erosion protection material upon delivery to the site. The Contractor shall provide equipment and labor to assist the CQA Engineer in sampling, if requested, and shall provide access to all areas requiring testing. The Contractor shall repair any damage to finished Work caused by the CQA Engineer's sampling or testing activities at no cost to Owner.
- D. Quality Control testing (in accordance with Section 10.2) of the erosion protection material at the source shall be the responsibility of the Contractor.
- E. The CQA Engineer shall be responsible for checking the thickness of the erosion protection material layer during placement. However, thickness checking by the CQA Engineer does not relieve the Contractor of their responsibility to lay out and control the Work. The Contractor and CQA Engineer will cooperate with each other to the maximum degree possible.

10.2 Products

10.2.1 Materials

- A. Erosion protection material shall consist of sound, hard, durable, inert, uncoated particles of rock or gravel, free from organic matter and other deleterious material, satisfying the requirements of Table 2.1 for erosion protection rock, or as approved by the Engineer.
- B. Contractor shall submit a Quarry Certificate and gradation curve for material to CQA Engineer for approval prior to delivery of material to the site.

10.3 Execution

10.3.1 Placement

- A. Contractor shall place erosion protection material as shown on the Drawings.
- B. Soils excavated to allow for placement of diversion channel erosion protection will be backfilled and compacted in place after acceptance of erosion protection by the CQA Engineer.

10.3.2 Field Quality Assurance

- A. The CQA Engineer will verify the gradation and the final thickness of erosion protection material to determine compliance with this Specification. Testing will be carried out in accordance with the requirements set forth by the Engineer.
- B. If the CQA Engineer's test results indicate Work does not meet the requirements of the Specifications, the CQA Engineer will establish the extent of nonconforming area. The nonconforming area shall be reworked or replaced by the Contractor, at their expense, until acceptable test results are obtained.
- C. The Contractor shall be aware of all field quality assurance testing activities, as these may affect their schedule, and they shall comply with the requirements of these Specifications.

10.3.3 Protection of Work

- A. After erosion protection material has been placed, the Contractor shall maintain it free of soils, ruts, depressions, and damage resulting from the hauling and handling of any material, equipment, tools, etc.
- B. The Contractor shall use all means necessary to protect all materials and all partially completed and completed Work of these Specifications.
- C. In the event of damage, the CQA Engineer will identify any areas requiring repair, and the Contractor shall make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

10.3.4 Survey Control

Contractor's Surveyor shall provide a Record Drawing to the Owner of the final location and elevation of the top of the erosion protection layer along the impoundment embankment outsoles and the diversion channel.



